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Land of Chamise and Pines

Historical Accounts and Current Status of Northern Baja California's Vegetation

Richard A. Minnich and
Ernesto Franco Vizcaíno

University of California Press

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Frontispiece. The rugged northern Sierra San Pedro Mártir.

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To Maria and Sharon

Contents

List of Illustrations, ix
List of Tables, xi
Acknowledgments, xii

INTRODUCTION 1

1 PRESENT-DAY VEGETATION OF NORTHERN BAJA CALIFORNIA 4
Physiography, 4
Climate, 6
Plant communities, 8
Exotic annual grassland, 9
Coastal sage scrub/maritime desertscrub, 9
Chaparral, 14
Closed-cone conifer forest, 15
Coast live oak woodland and riparian forests, 15
Pinyon forest, 16
Mixed-conifer forest, 16
Desertscrub, 17

2 EVENTS LEADING TO SPANISH EXPLORATIONS 18
Interpreting the Spanish diaries, 22
Eighteenth-century Spanish "botany," 23
Late-nineteenth-century surveys, 26
Analyzing the journeys, 26

3 VEGETATION AT EUROPEAN CONTACT 31
Linck (1766) and Portolá Expeditions (1769) from the Central Desert to the Sierra San Pedro Mártir, 31
Linck's explorations of the Sierra San Pedro Mártir and the Sonoran Desert, 39
Franciscan journeys to San Diego (1769), 41
Sierra San Pedro Mártir foothills, 42

Central basins, 47
North coast, 49

4 EXPLORATIONS OF THE INLAND MOUNTAINS AND SONORAN DESERT 56
Longinos-Martínez's traverse of the Sierra San Pedro Mártir (1792), 56
Arrillaga's first journey: to Santa Catarina (1796), 67
Arrillaga's second journey: to San Felipe (1796), 72
Arrillaga's third journey: to the Sierra Juárez, Valle San Rafael, and Valle Guadalupe (1796), 81
Expedition to the mission, 81
Return trip through the Sierra Juárez, 84
Arrillaga's fourth journey: to the Colorado River and San Diego (1796), 98

5 EUROPEAN LAND-USE, NATURAL DISTURBANCE, AND VEGETATION CHANGE 100
Evaluating historical vegetation changes, 100
Land-use history, 102
Land-use impacts on vegetation, 103
Livestock grazing, 105
Mining operations, 109
Cordwood cutting for fuelwood, 109
Logging, 110
Naturalization of exotic grasslands, 111
Wildland fire, 115
Ignition sources versus system-regulation of the fire regime, 117

6 THE STABILITY OF ECOSYSTEMS 122
Desertscrub, 122
Pinyon forest, 124
Mixed-conifer forest, 127
Closed-cone conifer forest, 128
Coast live oak woodland and riparian forests, 130
Coastal sage scrub/maritime desertscrub, 131
Chaparral, 133

7 THE FUTURE ROLE OF FIRE IN NORTHERN BAJA CALIFORNIA 136

Appendix A, 139
Appendix B, 145
Literature Cited, 153

Illustrations

Maps

1. Map of northern Baja California, 5
2. Detailed maps of eighteenth-century Spanish explorations and place names:
   (A) latitude 30°N to 31°N, 27
   (B) latitude 31°N to 32°N, 28
   (C) north of latitude 32°N, 29
3. Vegetation of northern Baja California with the routes of the late eighteenth-century explorers (in pocket)

Plates

Frontispiece. The rugged northern Sierra San Pedro Mártir
1. Desertscrub 25 km southeast of El Rosario, 35
2. View north toward the southern Sierra San Pedro Mártir, 35
3. *Brahea armata* oasis at El Palmarito, 36
4. *Juniperus californica* near San Miguel, 36
5. Aerial view of the eastern escarpment of the Sierra San Pedro Mártir, 50
6. Aerial photograph of Serra's "rock-ribbed hill," 50
7. Maritime desertscrub on the east side of Valle San Telmo, 51
8. View east across Valle San Telmo, 51
9. Valle San Vicente, 52
10. Valle Santo Tomás, 52
11. Arroyo la Grulla, 53
12. Outpost of *Agave shawii* near El Rosarito, 53
13. Aerial photograph of the west slope of the Sierra San Pedro Mártir, 61
14. La Grulla Meadow, 62
15. La Encantada meadow bordered by Jeffrey pine, 62
16. Landsat image of the Sierra San Pedro Mártir, 63
17. Santa Rosa meadow, 63
18. Mixed conifer forest of the high Sierra San Pedro Mártir, 64
19. Open pine forest at Vallecitos, 64
20. La Concepción, 65

21. Graveyard at Santa Catarina, 76
22. The settlement of El Alamo, 76
23. Narrow pass through the transverse range, Valle la Trinidad, and the Sierra San Pedro Mártir plateaus, 77
24. Vista from the crest of the Sierra San Pedro Mártir, 78
25. *Cercidium floridum* tree set on fire by a fuelwood gatherer, 78
26. Valle San Felipe and the eastern escarpment of the Sierra San Pedro Mártir, 79
27. Valle San Felipe in 1987, 79
28. Paso San Matías, 80
29. Jeffrey pine forest between Santa Isabel and Laguna Hanson, 89
30. Desertscrub along Arroyo Grande, 90
31. Laguna Hanson encircled by Jeffrey pine forest, 90
32. Cañon la Milla (El Tajo), 91
33. Pinyon forest on the La Rumorosa-El Topo plateau, 91
34. Aerial photo mosaic of Arroyo el Barbón, 92
35. Chamise and manzanita chaparral in Arroyo el Barbón, 93
36. The Indian village of La Huerta, 93
37. Map of Valle de San Rafael drawn by Don Raimun in 1864, 94
38. The same vegetation features in 1972, 95
39. Valle Ojos Negros with the Sierra Juárez plateaus in the skyline, 96
40. Vineyards at the east end of Valle Guadalupe, 96
41. *Washingtonia filifera* oasis at Cañon Guadalupe, 97
42. Petroglyphs within the territory of modern *Kiliwa* Indians, 106
43. *Kiliwa rancheria* near Tepi in 1969, 106
44. Spring cattle drive through desertscrub, 118
45. Forest fire near La Puerta, 119
46. Chaparral fire mosaic in the southern Sierra San Pedro Mártir, 119

Tables

1. Vegetation classification of northern Baja California, 10
2. The distances covered by eighteenth-century Spanish journeys, 22
3. Crespi's latitudes and corrections, 24
4. Summary of vegetation descriptions by Linck (1766), Crespi (1769), and Serra (1769) from San Fernando Velicatá to the southern Sierra San Pedro Mártir, 32
5. Summary of vegetation descriptions by Linck (1766) of the southern Sierra San Pedro Mártir and Sonoran Desert, 40
6. Summary of vegetation descriptions by Crespi and Serra (1769) from the Sierra San Pedro Mártir to San Diego, 42
7. Summary of vegetation descriptions by Longinos-Martínez (1792) of the Sierra San Pedro Mártir, 57
8. Tree circumferences in three one-acre plots in mixed conifer forests, 68
9. Summary of vegetation descriptions in Arrillaga's first journey to Santa Catarina (1796), 70
10. Summary of vegetation descriptions in Arrillaga's second journey to San Felipe (1796),73
11. Summary of vegetation descriptions in Arrillaga's third journey to Santa Catarina (1796), 82
12. Summary of vegetation descriptions by Arrillaga's fourth journey to the Colorado River and along the eastern base of the Sierra Juárez (1796), 98
13. Population data for Baja California,104
14. Estimates of carrying capacities at four ejidos, 110
15. Newspaper reports of fire in northern Baja California, 116
16. Durations of selected fires, 120

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INTRODUCTION

The Baja California peninsula north of the thirtieth parallel is covered by grasslands, shrublands, conifer forests, and desertscrub similar to that in Alta California (Wiggins 1960, 1980; Rzedowski 1978; Minnich 1987a). At the same time, an enduring traditional land-use system has resulted in a distinctive relationship between humans and nature that is unique within the Californian floristic province. Until recently, most of Baja California's biological environment was not as intensively exploited as Alta California, nor were its wildlands under formal protection. Indeed, the vegetation, protected by isolation, has a pristine character rarely seen in Alta California. In México, Baja California is referred to as the Frontera. This term may seem incongruous for a modern state that has large cities—Tijuana, Mexicali, and Ensenada—and extensive commercial agriculture in the coastal lowlands and Valle Mexicali. Yet, until the end of World War II, northern Baja California remained largely politically and economically isolated and undeveloped, despite its proximity to the rapidly expanding economy of Alta California (Henderson 1964). Within México, the Frontera was a distant outpost from Mexico City.

In the nineteenth century, Baja California had experienced a few mining strikes, but the ores played out within a few years and the miners dispersed. Except around the Dominican missions, agriculture did not exist in these semiarid lands until the 1880s. The total population of the entire peninsula of Baja California, which covers an area nearly equal to that of Alta California, was counted in the thousands into the early twentieth century (Henderson 1964). The region's remoteness has helped to preserve a rural land-use pattern dating back to the Dominican mission period: mostly cultivation of fruit trees and gardens near ranchsteads and transhumance cattle grazing by families rooted in the region's open-range livestock economy. Wildland fires in the mountains are uncontrolled to this day, and deliberate burning is still practiced by *vaqueros* and farmers. Small Indian populations, still speaking native languages, continue to hunt and gather in the most isolated mountains.

In contrast, over the past two centuries Alta California's ecosystems underwent a cycle of intense human exploitation parallel to that in many other areas of the western United States (Lockmann 1981; Pyne 1982). The Gold Rush in 1849 drew large numbers of Anglo-Americans to Alta California, and when the mines were exhausted, the well-watered lands permitted a transition to agriculture. Forests were logged for construction, fuelwood was culled for mining operations and domestic use, and rangelands were grazed by livestock. Exotic annuals, introduced by the Spanish missionaries, swept the region and began to displace native herbaceous ecosystems. By the end of the century, after forests and

1

rangelands had been exploited across the United States (Robinson 1975), a growing awareness of the need to conserve those areas arose. Public concern for a variety of issues including watershed protection, wildfire control, and forest protection resulted in large areas of the public domain being placed into national parks and national forests. Logging and grazing were managed or prohibited; fire control was instituted.

The protectionist management systems led to unintended changes in Alta California's ecosystems: forests grew thicker, fires increased in severity, and storm runoff caused accelerated erosion. The protectionist policies failed to recognize that in this Mediterranean-type climate fire was a natural part of ecosystem evolution, and periodic fire was necessary for the maintenance of plant communities (Barbour and Minnich 1998). Today, the role of natural disturbance is now widely recognized; however, modern ecosystems north of the U.S.-Mexican border have been so altered that ecologists find it difficult to determine the nature of past disturbance regimes, vegetation structure, and dynamics.

Large parts of the Baja California landscape remain little altered from the late eighteenth century, when Europeans first described them. Because the region has not experienced the same utilization or protectionist management policies as has Alta California, the potential divergence in the disturbance and ecology of similar ecosystems in the two countries may provide insight into the nature of historical vegetation change in Alta California and into the response of vegetation to traditional land use in Baja California. At the same time, there is concern that practices such as deliberate burning and livestock grazing on the Mexican side of the international boundary are causing directional vegetation changes that would not occur given the same conditions that existed before Europeans colonized the region (e.g., Keeley et al. 1989).

There has been extensive research on changes in the vegetation in the United States, including of Alta California, but studies in northern Baja California are lacking, partly because historical databases are scarce. Studies of vegetation change in the southwestern United States have employed a variety of methods to determine historical changes: repeat aerial photographs, repeat ground photography, historical landscape descriptions of maps, U.S. Public Land Survey field notes, and permanent vegetation plots (see Hastings and Turner 1965a; Humphrey 1987; Bahre 1991). In Baja California, the historical sources are not nearly as complete. Aerial photography dating to 1938-1942 reveals evidences of disturbance and vegetation change as early as 1920 (Minnich and Bahre 1995; Minnich and Chou, 1997). Ground photographs, archived at the Zárate Family Archives in Ensenada and at the Instituto de Investigaciones Históricas, Universidad Autónoma de Baja California in Tijuana, are scarce and seldom date to the late nineteenth century (Chaput et al. 1992). The Nelson and Goldman Expedition of Baja California, which was sponsored by the Bureau of the Biological Survey of the U.S. Department of Agriculture, published rare old photographs (Nelson 1921). Land-survey notes and permanent vegetation plots do not exist. Important historical sources for determining the early vegetation of Baja California are the diaries of Spanish explorers. The diaries of several explorers in the expeditions of Gaspar de Portolá (1769-1770) and Juan Bautista de Anza (1772-1776) have been consulted for evidence of vegetation change in Alta California over the past two centuries. The most important accounts of Alta California vegetation in the Anza expeditions were recorded in the diaries of Anza, Díaz, Garcés, and

Palóu (Bolton 1927, 1930), and from the Portolá expedition the diaries of Crespi (Bolton 1927) and Serra (Tibesar 1955). These studies evaluate such themes as the replacement of indigenous herbaceous communities by Mediterranean exotics, the invasion of chaparral and coastal sage scrub communities by exotic grasslands, changing fire regimes in California brushlands, and the possible retreat of montane conifer forests (Dodge 1975; Wester 1981; Timbrook et al. 1982; Burcham 1982; Cox 1984; Minnich 1988).

The diaries of these and other concurrent expeditions in Baja California have not previously been consulted by history-minded scholars with the same scrutiny as have diaries in Alta California, because ecological research on the Mexican side has been limited. In the northern peninsula, the vegetation was described in five explorations during the latter half of the eighteenth century. The Sierra San Pedro Mártir was described in the diaries of Winceslaus Linck in 1766 and José Longinos-Martínez in 1792 (Burrus 1966; Simpson 1938, 1961). Juan Crespi and Junipero Serra of the Portola expedition provide accounts of the plains and mountains along the coast (Bolton 1927; Tibesar 1955). José Joaquin Arrillaga's four journeys in 1796 provide numerous descriptions of plant cover over much of northern Baja California (Tiscareño and Robinson 1969). These surveys give a relatively complete picture—from broad-scale distributions of plant communities to specific detail on species ranges, and local patterning of plant communities—of the three primary ecosystems of the region: the extensive mediterranean scrublands, mountain pine forests, and vast desertscrub to the east of the sierra.

More recently, American- and British-sponsored expeditions crossing the Baja California Peninsula have also provided detailed accounts of the vegetation, including that in the areas crossed by Spanish explorers.

In this volume, we propose to reconstruct the vegetation of northern Baja California as first seen by Europeans in the late eighteenth century by comparing these accounts with the present vegetation as mapped from aerial photographs and as seen on the ground. Chapter 1 describes the present-day vegetation in relation to the physical landscape and climate. Chapter 2 reviews the historical events leading to the late-eighteenth-century Spanish land expeditions, with an emphasis on translation of eighteenth-century botanical vocabulary, and our approach toward relocating vegetation descriptions in the diaries. Chapter 3 examines the vegetation recorded in published diaries written at European contact by Linck, Crespi, and Serra. Chapter 4 traces the accounts of vegetation two decades later by Arrillaga and Longinos-Martínez in the inland basins, mountains, and deserts. Chapter 5 assesses vegetation changes in northern Baja California over the past two centuries, and chapter 6 discusses the stability of present-day ecosystems.

The primary objectives of this volume are (1) to produce a detailed map of the modern vegetation of northern Baja California; (2) to describe the probable vegetation of northern Baja California when Europeans first settled that area; (3) to evaluate the extent to which the isolation, traditional land uses, and lack of fire control in this region has led to vegetation change over two centuries since European contact; and (4) to assess, from the Mexican experience, the impact of American land-use and protectionist policies on comparable mediterranean ecosystems north of the border.

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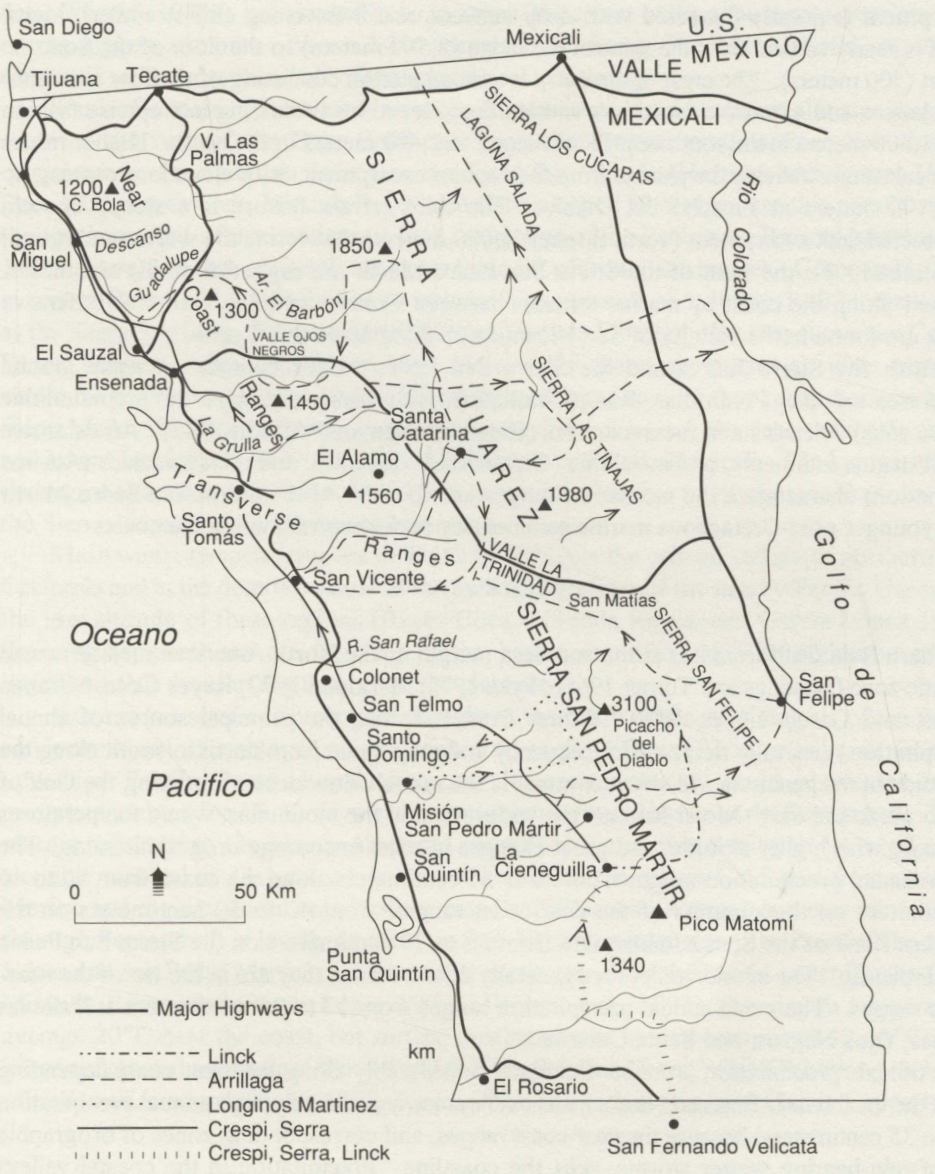
PRESENT-DAY VEGETATION OF NORTHERN BAJA CALIFORNIA

Throughout the upper peninsula of Baja California, grasslands, chaparral, conifer forest, and desertscrub vegetation are strikingly similar to those in the State of California to the north, both in the distribution of ecosystems and in their relationship to topography and the mediterranean climate of the region. The mountain topography encourages conspicuous zonation of communities, which are further modified by orographic precipitation zones and rain shadows. The complexity of the terrain encourages fine-grained patchiness in the distributions of plant cover.

PHYSIOGRAPHY

Northern Baja California (Map 1) is a hilly and mountainous region of the Peninsular Range geomorphic province (Gastil, Phillips, and Allison 1975). Near the Pacific coast is a rugged discontinuous chain of ranges (summit altitudes: 1,200 to 1,500 meters) that include the Cerro Bola west of Valle las Palmas, and an unnamed, north-to-south chain of mountains trending southward from Valle Guadalupe to east of Santo Tomás. In this book, this area is termed the "near-coast ranges." About 100 kilometers inland is the Sierra Juárez proper, a relatively undissected, westward-tilting plateau of greater altitude (1,200 to 1,800 meters), which is a southern extension of the Laguna Mountains of San Diego County in California. The dissected and precipitous eastern escarpment of this block has a vertical relief of 1,000 to 1,500 meters from the mountain divide to the margin of the Sonoran Desert. Aligned between the near-coast ranges and the Sierra Juárez are several alluvial valleys and low plateaus, including Valle Ojos Negros and the plains between El Alamo and Santa Catarina. Valle Guadalupe slices through the near-coast ranges to the Pacific Ocean at El Sauzal, ten kilometers north of Ensenada.

The southern margins of the near-coast ranges, the Sierra Juárez, and the plain of El Alamo/Santa Catarina are bordered by the Agua Blanca fault, which is traceable as a series of steep east/west-bearing ranges (altitudes: 1,000 to 1,400 meters) from Punta Banda at the south margin of Ensenada Bay to the mountains along the northern rim of Valle la Trinidad and eastward through Valle San Matías. These ranges, also unnamed, are referred to as the "transverse ranges."



Map 1. Map of northern Baja California.

Immediately south of Valle San Matías is the Sierra San Pedro Mártir, a spectacular fault-bound range that extends southeastward 60 kilometers to a point 50 kilometers east of San Quintín (Gastil, Phillips, and Allison 1975; O'Conner and Chase 1989). This range has three distinct terrain sectors: eastern escarpment, crest, and western flank. The eastern escarpment is greatly dissected with deep canyons and intervening cliff-straddled ridges. Relief is nearly vertical from the spine of the range (2,500 meters) to the floor of the Sonoran Desert (500 meters). The crest of the sierra is a broad plateau consisting of shallow alluvium-filled basins and extensive meadows with surface elevations increasing in stepwise fashion from 1,600 meters in the south near Pico Matomí to 2,400 meters in the north. Higher ridges and local summits divide the plateau from the eastern escarpment, with elevations ranging up to 3,100 meters at Picacho del Diablo. The third terrain feature is a steep, smooth, undissected fault escarpment (vertical relief: 1,000 meters) that forms the western margin of the plateau. To the west of the Sierra San Pedro Mártir are rugged foothills and mesas, rimmed along the coast by marine terraces between Colonet and San Quintín. Extensive plains are found in the vicinity of San Vicente and along Valle San Telmo.

Both the Sierra Juárez and the Sierra San Pedro Mártir contain extensive granite substrates of the Peninsular Range batholith with local outcrops of prebatholithic (Cretaceous) volcanics and metavolcanics (Gastil, Phillips, and Allison 1975). An extensive belt of marine sediments, prebatholithic (Cretaceous) volcanics, and metavolcanics (Alisitos Formation) characterize the near-coast ranges and foothills of the Sierra San Pedro Mártir with younger post-Cretaceous marine sedimentary rocks exposed along the coast.

CLIMATE

Northern Baja California lies at the southern margin of the North American mediterranean climatic zone (Hastings and Turner 1965b; Pyke 1972; Markham 1972; Reyes Coca, Miranda Reyes, and García López 1990). Winter frontal storms, the principal source of annual precipitation, generally decrease in frequency and magnitude from north to south along the west side of the peninsula. In sharp contrast is the rain-shadow desert bordering the Gulf of California to the east. Moist habitats are widespread in the mountains, where temperatures decrease with higher altitude, and great changes in relief encourage orographic rains. The mean annual precipitation ranges from 20 to 35 centimeters along the coast, from 30 to 40 centimeters on the summits of the near-coast ranges, from 40 to 50 centimeters on the western flank of the Sierra Juárez, and from 50 to 70 centimeters on the Sierra San Pedro Mártir plateau. The interior valleys are generally drier because they are in the lee of the near-coast ranges. The mean annual precipitation ranges from 17 to 25 centimeters at Valle las Palmas, Ojos Negros, and Santa Catarina.

Annual precipitation amounts fluctuate considerably along the west coast depending upon the local relief. Ensenada and adjacent valleys have a relatively high annual precipitation (25 to 35 centimeters) because the near-coast ranges, and corresponding zones of orographic lift of rain-bearing winter storms, skirt the coastline. Precipitation in the coastal valleys decreases rapidly south of Ensenada as the high terrain shifts inland to the Sierra San Pedro

Mártir, which is 100 kilometers from the Pacific; for example, the average annual precipitation along the San Quintín Plain is only 15 to 20 centimeters.

Snowfall occurs infrequently except in the highest mountains. The average annual water equivalent of snowfall in the Sierra Juárez, based upon storm freezing levels from radiosonde data (Minnich 1986a), is estimated to be less than 25 percent of the annual precipitation, even on the highest summits. Above 2,200 meters in the Sierra San Pedro Mártir, snowfall is estimated to be more than half of the annual precipitation.

South of latitude 30°, the mediterranean climate is replaced by desert climates that span most of the rest of the Baja California peninsula (annual precipitation: less than 15 centimeters). Precipitation decreases rapidly at this latitude (Hastings and Turner 1965b; Pyke 1972; Reyes Coca, Miranda Reyes, and García López 1990) because this parallel marks the southern limit of the continuous high mountains of the Peninsular Ranges (greater than 1,500 meters) and thus of significant orographic lift of frontal air masses. Comparable relief in central Baja California is limited to isolated high summits of 1,400 to 1,600 meters, such as the Sierra San Borja, Sierra la Asamblea, and Sierra la Libertad, that rise above the Central Desert between latitudes 28° and 30°. Here, moist storm air masses circulate eastward across the peninsula with little orographic lift and precipitation until they reach Arizona or the Sierra Madre Occidental of northwestern Mexico. Farther inland, the desert climates extend northward to basins west of the Gulf of California and Valle Mexicali. The hyperaridity of this region (annual precipitation: less than 6 centimeters) is due to strong rain shadows from the Sierra Juárez and San Pedro Mártir.

Mean winter temperatures are mild (12 to 14°C) in the coastal valleys of northern Baja California and in the deserts because of the moderating effect of the nearby Pacific Ocean and the low altitude of these regions (Reyes Coca, Miranda Reyes, and García López 1990). Freezing temperatures are frequent in the higher mountains due to nighttime ground inversions that develop regularly over the plateaus.

Summer is a season of protracted drought as the result of the subsiding air of the Pacific anticyclone and of stable air masses related to onshore flow of cool marine air from the upwelling Pacific Ocean. Local afternoon thunderstorms may occur above the inland mountain ranges for 15-40 days each year, mostly from July to early September. These storms result from the North American monsoon, a northward-moving layer of moist, unstable tropical air that extends periodically into northern Baja California from mainland Mexico and the equatorial region of the east Pacific Ocean. Average summer rainfall (July through September) is locally as great as 5 to 10 centimeters along the crest of the Sierra Juárez and San Pedro Mártir but is less than 1 centimeter along the Pacific coast (Reyes Coca, Miranda Reyes, and García López 1990; Minnich et al., 1993). Maximum temperatures average 20°C near the coast, but surface heating results in temperatures of 30-40°C in the inland valleys and mountains. Temperatures in the Sonoran Desert, which is beyond the reach of marine air, are typically 40-45°C (Reyes Coca, Miranda Reyes, and García López 1990).

PLANT COMMUNITIES

Detailed vegetation maps of northern Baja California necessary for the purposes of this book are lacking. The earliest vegetation maps of northern Baja California were made by Nelson (1921) and Meigs (1935), but they were generalized from field studies at certain localities or along specific routes. More recently, the vegetation in the northern peninsula was mapped by Brown and Lowe (1980) as part of a regional map of the American Southwest (scale: 1:1,000,000). The map delimits biomes in accordance with Merriam's life-zone concept (Lowe and Brown 1982). The map data are multivariate interpretations: they are not strictly vegetation maps because plant community distributions are based on inferences drawn from altitude, terrain, and animal constituents. The maps are also deduced from second-hand interpretations of other regional surveys, including national maps on topographic sheets (scale: 1:250,000; Flores-Mata et al. 1971; Instituto Nacional de Estadística, Geografía y Informática [INEGI], Aguascalientes, México). Inferences of distributions from abiotic factors have led to map inaccuracies: for example, Jeffrey pine forest is shown to extend from known stands at Laguna Hanson to the higher southern peaks of the Sierra Juárez, where none is found.

A vegetation map prepared by the Commission for the Determination of Regional Carrying-Capacity Coefficients (COTECOCA 1981) in Ensenada focuses upon the carrying capacity of the vegetation for livestock. Manuscript vegetation maps of most of northern coastal Baja California have also been prepared by P. Rojas (on file at Universidad Autonoma de Baja California, Ensenada). The distribution of forest trees in northern Baja California was mapped from aerial photographs (Minnich 1987a). Similarly, we produced a map of the vegetation of northern Baja California (Map 3, back pocket) from 1938, 1956, 1966, 1972 black-and-white photographs and from 1991 color aerial photographs using a roll-film stereoscope with 3x and 8x magnification, a mirror stereoscope, and a standard pocket stereoscope.

Trees and shrubs were identified on the basis of their crown perimeter and apex configurations, vertical structure, shadows, and color. Once the classification was decided upon, the vegetation was systematically delimited on the photographs, one type at a time, throughout the region. The photographs were then reexamined for the next vegetation type, and so on. Hence, the photographs were examined as many times as there are vegetation types. This type-mapping approach permitted us to concentrate on the diagnostic characteristics of each community, as opposed to conventional regional mapping, in which the entire diversity of types is mapped photograph by photograph, requiring the simultaneous memory of diagnostic criteria for all types. Plant recognitions were not made on the basis of abiotic factors, such as slope and altitude. The methods of interpretation and field verification are discussed in Minnich (1987a and 1988).

The vegetation typology (Table 1) requires that plant communities form at least 20 percent cover for shrublands and 10 percent cover for forests. A map unit covers a minimum area of 50 hectares. The choice of vegetation units reflects their degree of clarity on aerial photographs. Thus, forests could often be delimited to species level, whereas smaller brushland units were mapped on physiognomic grounds (e.g., deciduous cover of coastal sage

scrub versus evergreen chaparral). The classification is also adapted to descriptions of early explorers. Coastal estuary vegetation, for example, was not defined because the Spanish diaries said little about these communities; however, we mapped palm oases in detail because the eighteenth-century diaries frequently contain comments about them.

The distribution of plant communities in northern Baja California (Map 3, back cover) shows a broad altitudinal zonation similar to that in southern California (Hanes 1988; Thorne 1988; Barbour 1988; Minnich 1987a; Peinado et al., 1994 and 1995a,b). Grasslands, coastal sage scrub, and maritime desertscrub in the coastal valleys and foothills are replaced by chaparral and conifer forests in the higher mountains. Evergreen oak woodlands and winter-deciduous riparian forests follow the major arroyos. North of latitude 31° 30' are two mesic zones of dense chaparral and oak woodlands: one along the axis of the near-coast ranges extending inland to the Sierra San Pedro Mártir, the other along the upper western flank of the Sierra Juárez. Between them is a series of semiarid basins between Valle las Palmas and Valle la Trinidad that are covered with open scrub communities. Sonoran desert communities extend to the base of each of the Peninsular Range escarpments south to latitude 30°, then expand westward beneath the Sierra San Pedro Mártir to the Pacific coast (Peinado et al 1995a). These communities are found at higher altitudes southward from the international boundary to the Central Desert, and there is also a gradual turnover of species, and patterns of dominance, within all the types. Local vegetation patterning also reflects slope, aspect, and substrate, as well as distance from the Pacific Ocean. Given below are broad distributions, structures, and dominant species of the primary ecosystems in the northern peninsula. Further details on species composition are given in the plant classification in Table 1. A glossary of English and Spanish plant names is given in Appendix A.

Exotic Annual Grassland. The northernmost coastal valleys are covered by grasslands comprising exotic annuals. This community consists of winter annuals introduced mostly from lands surrounding the Mediterranean Sea, including southern Europe, North Africa, and the Middle East (Heady 1988; Huenneke and Mooney 1989; D'Antonio and Vitousek 1992). It includes *Bromus rubens*, *B. diandrus*, *Avena fatua*, *A. barbata*, *Erodium cicutarium*, *Brassica geniculata*, and a few natives such as *Hemizonia* spp. Grasslands prevail in areas of deep loamy soils and alluvium between Tijuana and Valle las Palmas and in uncultivated portions of Valle Guadalupe, the coastal plains of Ensenada, Valle Ojos Negros, and Valle San Vicente.

Coastal Sage Scrub/Maritime Desertscrub. Foothills and lower mountain slopes below 1,000 meters are blanketed mostly by coastal sage scrub—also termed *matoral* in Baja California—which consists of open-to-contiguous stands of aromatic, drought-deciduous subshrubs that are 0.5 to 1.5 meters tall mixed with woody deciduous shrubs and a few succulents. Maritime desertscrub also consists of an uninterrupted cover of subshrubs, but is much richer in succulent taxa (Peinado et al. 1995b).

Coastal sage scrub is widespread in the near-coast ranges and in the Sierra Juárez north of Valle Guadalupe. To the south, it occurs along the near-coast ranges east of Ensenada, on hillslopes surrounding San Vicente, and along the west base of the Sierra San Pedro Mártir. This type of scrub is almost entirely absent from the high inland basins of Ojos Negros, Santa Catarina, and Valle la Trinidad. Important subshrubs include *Artemisia*

Table 1. Vegetation classification of northern Baja California north of lat. 30° (stand areas rounded off to 100 hectares; species listed in a general decreasing order of importance)

MEDITERRANEAN ANNUAL GRASSLAND (77,000 hectares): *Bromus rubens*, *B. diandrus*, *Avena barbata*, *Brassica geniculata*, *Erodium cicutarium*, *Schismus barbatus*, *Hemizonia* spp.

MOUNTAIN MEADOW (8,900 hectares): *Juncus* spp., *Carex* spp., *Poa annua*, *Linanthus melingii*, *Linum lewisii*, *Potentilla wheeleri*, *Muhlenbergia*, spp., *Epilobium adenocaulon*, *Astragalus gruinus*, *Oenothera californica*, *Berula erecta*, *Cirsium foliosum*.

COASTAL SAGE SCRUB (561,300 hectares): *Eriogonum fasciculatum*, *Artemisia californica*, *Salvia apiana*, *S. munzii*, *Encelia californica*, *Lotus scoparius*, *Agave shawii*, *Fraxinus trifoliata* [south of Valle las Palmas], *Aesculus parryi* [south of Descanso], *Malosma laurina*, *Rhus integrifolia*, *Opuntia littoralis*.

MARITIME DESERTSCRUB (306,100 hectares): *Artemisia californica*, *Ambrosia chenopodifolia*, *Viguiera laciniata*, *Rosa minutifolia*, *Lotus scoparius*, *Fraxinus trifoliolata*, *Aesculus parryi*, *Simmondsia chinensis*, *Ephedra californica*, *Agave shawii*, *Yucca schidigera*, *Bergerocactus emoryi*, *Machaerocereus gummosus*, *Myrtillocactus cochal*, *Opuntia cholla*, *O. prolifera*, *Mammalaria dioica*.

GREAT BASIN SAGE SCRUB (5,800 hectares): *Artemisia tridentata*.

CHAMISE CHAPARRAL (311,300 hectares)

Near-coast ranges: *Adenostoma fasciculatum*, *Ceanothus verrucosus*, *C. greggii*, *Cercocarpus betuloides*, *Xylococcus bicolor*, *Ornithostaphylos oppositifolia* [south of Valle Guadalupe], *Rhus ovata*, *Malosma laurina*, *Fraxinus trifoliata* [south of Valle las Palmas], *Aesculus parryi* [south of Descanso].

Sierra Juárez/Sierra San Pedro Mártir: *Adenostoma fasciculatum*, *Ceanothus greggii*, *C. cuneatus*, *Rhus ovata*, *Arctostaphylos pungens*, *Quercus cedrosensis* [south of San Vicente], *Prunus ilicifolia*, *Yucca schidigera*.

CHAMISE/CALIFORNIA JUNIPER CHAPARRAL (183,200 hectares): *Adenostoma fasciculatum*, *Ceanothus greggii*, *Ephedra* spp. *Juniperus californica*, *Yucca schidigera*, *Simmondsia chinensis*, *Ephedra nevadensis*, *Artemisia tridentata*, *Acacia greggii*, *Happlopappus* spp., *Opuntia basilaris*.

RED SHANK CHAPARRAL (135,200 hectares): *Adenostoma sparsifolium*, *A. fasciculatum*, *Ceanothus greggii*, *Rhus ovata*, *Yucca schidigera*.

Table 1. Vegetation classification of northern Baja California (continued)

MIXED CHAPARRAL (91,100 hectares)

Near-coast ranges: *Ceanothus oliganthus*, *Adenostoma fasciculatum*, *Ornithostaphylos oppositifolia* [south of Ensenada], *Comerostaphylos discolor*, *Quercus berberidifolia* [north of Ensenada], *Heteromeles arbutifolia*, *Fraxinus trifoliata* [south of Valle las Palmas], *Aesculus parryi* [south of Descanso].

Sierra Juárez: *Ceanothus leucodermis* [north of Laguna Hanson], *Arctostaphylos glauca*, *A. peninsularis*, *Quercus berberidifolia*, *Q. cornelius-mulleri* [south of Nejí].

PENINSULA MANZANITA CHAPARRAL (11,800 hectares): *Arctostaphylos peninsularis*, *Ceanothus greggii*, *Nolina palmeri*, *Adenostoma fasciculatum*, *Garrya grisea* [San Pedro Mártir endemic].

DESERT CHAPARRAL (not mapped, see distribution in Parry pinyon and singleleaf pinyon forest)

Sierra Juárez: *Rhus ovata*, *Adenostoma sparsifolium*, *Quercus cornellius-mulleri*, *Q. turbinella* [near international border], *Ceanothus greggii*, *Rhamnus ilicifolia*, *Yucca schidigera*, *Agave deserti*, *Nolina parryi.*

Sierra San Pedro Mártir: *Quercus chrysolepis*, *Arctostaphylos peninsularis*, *Rhus ovata*, *Quercus peninsularis*, *Q. cornelius-mulleri*, *Agave deserti*, *Nolina palmeri*.

KNOBCONE PINE:[1] *Pinus attenuata*, chamise chaparral, mixed chaparral.

BISHOP PINE:[1] *Pinus muricata*, chamise chaparral, coastal sage scrub.

TECATE CYPRESS:[1] *Cupressus guadalupensis* spp. *forbesii*, chamise chaparral, mixed chaparral.

ARIZONA CYPRESS:[1] *Cupressus arizonica* var. *stephensonii*, chamise chaparral, peninsula manzanita chaparral.

COULTER PINE (1,400 hectares): *Pinus coulteri*, *Quercus chrysolepis*, mixed chaparral, chamise chaparral, peninsula manzanita chaparral.

COAST LIVE OAK (24,800 hectares): *Quercus agrifolia*, mediterranean annual grassland, chaparral.

Table 1. Vegetation classification of northern Baja California (continued)

CANYON LIVE OAK (9,100 hectares): *Quercus chrysolepis*, mixed chaparral, red shank chaparral, peninsula manzanita chaparral.

RIPARIAN FOREST (16,000 hectares): *Populus fremontii*, *Platanus racemosa*, *Salix* spp., *Baccharis glutinosa*, *Happlopappus* spp.

QUAKING ASPEN:[1] *Populus tremuloides*.

PARRY PINYON (53,100 hectares): *Pinus quadrifolia*, desert chaparral.

MIXED PARRY PINYON/SINGLELEAF PINYON FOREST (53,600 hectares): *Pinus quadrifolia*, *P. monophylla*, desert chaparral.

SINGLELEAF PINYON FOREST (44,600 hectares): *Pinus monophylla*, desert chaparral.

PARRY PINYON FOREST/RED SHANK CHAPARRAL (58,700 hectares): numerous small stands of *Pinus quadrifolia* in red shank chaparral.

PARRY PINYON FOREST/CHAMISE CHAPARRAL (75,300 hectares): numerous small stands of *Pinus quadrifolia* in chamise chaparral.

MIXED PARRY PINYON/CALIFORNIA JUNIPER WOODLAND (12,100 hectares): *Pinus quadrifolia*, *Juniperus californica*, chamise chaparral.

JEFFREY PINE FOREST (47,700 hectares): *Pinus jeffreyi*, *Quercus peninsularis* [south of El Topo], *Arctostaphylos pringlei*, *A. pungens*, *A. patula*, *Artemisia tridentata*, *Salvia pachyphylla*, *Nolina palmeri*.

MIXED JEFFREY PINE FOREST (18,300 hectares): *Pinus jeffreyi*, *Abies concolor*, *P. lambertiana*, *Calocedrus decurrens*, *Quercus chrysolepis*, *Q. peninsularis*, *Arctostaphylos patula*, *Ceanothus cordulatus*, *Salvia pachyphylla*, *Symphoricarpos oreophyllus*, *Nolina palmeri*.

MIXED INCENSE CEDAR FOREST:[1] *Pinus jeffreyi*, *Abies concolor*, *Calocedrus decurrens*, *P. lambertiana*.

MIXED WHITE FIR FOREST (4,200 hectares): *Abies concolor*, *Pinus lambertiana*, *P. jeffreyi*, *Quercus chrysolepis*, *Arctostaphylos patula*, *Ceanothus cordulatus*, *Symphoricarpos oreophyllus*.

Table 1. Vegetation classification of northern Baja California (continued)

MIXED MOUNTAIN CYPRESS FOREST (2,400 hectares): *Cupressus montana, Abies concolor, Pinus lambertiana, P. jeffreyi, Quercus chrysolepis, Symphoricarpos oreophyllus, Holodiscus microphyllus.*

MIXED LODGEPOLE PINE FOREST (2,000 hectares): *Pinus contorta, P. jeffreyi, Abies concolor, Symphoricarpos oreophyllus, Arctostaphylos patula, Ceanothus cordulatus.*

SONORAN DESERTSCRUB (2,090,000 hectares): Mixture of creosote bush scrub and microphyllous woodlands: *Larrea tridentata, Olneya tesota, Cercidium floridum, Dalea spinosa, Fouquieria splendens, Prosopis glandulosa, Bursera microphylla, Ambrosia dumosa, Encelia farinosa, Hymenoclea salsola, Agave deserti, Echinocereus engelmanii, Opuntia echinocarpa, Bursera microphylla.*

CENTRAL DESERTSCRUB (108,000 hectares): *Fouquieria* (*Idria*) *columnaris, Pachycereus pringlei, Machaerocereus gummosus, Myrtillocactus cochal, Yucca valida, Ambrosia chenopodifolia, Lycium* spp., *Simmondsia chinensis, Agave shawii, Opuntia cholla, O. prolifera.*

PALM OASES (2,000 hectares): *Washingtonia filifera, Brahea armata.*

URBAN AREAS/AGRICULTURE (494,100 hectares).

[1] Vegetation types represented by point symbols. Thus, their total area cannot be calculated. All such communities cover less than 1,000 hectares.

californica, *Eriogonum fasciculatum*, *Salvia munzii*, and *Encelia californica*. South of Valle Descanso and Valle las Palmas, two tall woody deciduous shrubs, *Fraxinus trifoliolata* and *Aesculus parryi*, grow abundantly on north-facing exposures. Coastal sage scrub also contains a few evergreen sclerophyllous shrubs, notably *Malosma laurina*, *Rhus integrifolia*, and *Simmondsia chinensis* (Minnich 1983; Peinado et al. 1995b).

Maritime desertscrub grows extensively in the lower foothills west of the Sierra San Pedro Mártir and northward along the coast to near Erendira (Mooney 1988). Important species include the dominants of coastal sage scrub, as well as subshrubs with more southern or desert distributions, such as *Viguiera laciniata*, *Ambrosia chenopodifolia*, *Rosa minutifolia*, and *Prunus fasciculata*. The most common evergreen shrubs are *Simmondsia chinensis* and *Ephedra californica*, but *Malosma laurina* and *Rhus integrifolia* are still common along arroyos. Maritime desertscrub is made distinctive by the abundance and diversity of cacti, including *Bergerocactus emoryi*, *Machaerocereus gummosus*, *Myrtillocactus cochal*, *Mammillaria dioica*, and various *Opuntia* spp. Succulence is most pronounced on southern exposures. Near El Rosario, maritime desertscrub grades into Sonoran desertscrub. Here subshrubs form open cover and succulence is even more pronounced. In this area are the northernmost outposts of the well-known boojum tree (*Fouquieria columnaris*) and cardón (*Pachycereus pringlei*), two of the most conspicuous arboreal succulents of the Central Desert. *Prosopis glandulosa* is found along dry washes and dry basins.

Chaparral. Chaparral, an evergreen community of sclerophyllous shrubs in carpetlike stands, grows extensively above coastal sage scrub on infertile coarse-textured soils in the mountains of northern Baja California. Chaparral is widespread in the near-coast ranges at elevations above 400 to 800 meters, but stands descend to near sea level where steep, north-facing hillslopes reach cool coastal climates, as near Ensenada. A second belt covers the inland basins from El Alamo to Santa Catarina, as well as the western slopes of the Sierra Juárez, with some stands reaching the highest summits of 1,800 to 2,000 meters. South of Santo Tomás, stands become increasing patchy and occur mostly on northern exposures in the coastal foothills. Farther inland, an extensive belt covers the transverse range and western flank of the Sierra San Pedro Mártir at elevations above 900 to 1,200 meters. The composition of chaparral species varies in Baja California with elevation and slope exposure (Minnich 1983; Peinado 1994; Peinado et al. 1995b; Minnich and Chou 1997), as it does in southern California (Hanes 1971, 1988). *Adenostoma fasciculatum* chaparral grows on southern exposures of the near-coast ranges and on the lower altitudes of the Sierra Juárez and Sierra San Pedro Mártir. Mixed chaparral, which comprises a diverse mixture of species in the genera *Ceanothus*, *Arctostaphylos*, and *Quercus*, is widespread on northern exposures of near-coast ranges and higher elevations of the Sierra Juárez. Other common shrubs in both chamise and mixed chaparral include *Cercocarpus betuloides*, *Xylococcus bicolor*, *Malosma laurina*, *Rhus ovata*, and *Ornithostaphylos oppositifolia*. The drought-deciduous *Fraxinus trifoliolata* and *Aesculus parryi* grow in the lower margins of the chaparral belt.

Red shank chaparral *(Adenostoma sparsifolium)*, which greatly prefers granitic substrates, is widespread on the higher plateaus of the Sierra Juárez north of Santa Catarina and on the west slope of the Sierra San Pedro Mártir. Stands are also extensive in the basin

of El Alamo and Santa Catarina and more locally in the near-coast ranges at Sierra Blanca and south of Highway 3. At elevations above 1,800 meters in the southern Sierra Juárez and in the Sierra San Pedro Mártir, chamise and red shank chaparral is replaced by peninsula manzanita chaparral (*Arctostaphylos peninsularis*), which gives a distinct blue cast to these mountains when viewed from a distance.

In the semiarid basins near Santa Catarina and in the southern Sierra San Pedro Mártir are extensive stands of chamise in association with California juniper (*Juniperus californica*). These stands, usually open, are composed of shrubs common to the desert flanks of the Peninsular Ranges of southern California, including *Ephedra nevadensis*, *Simmondsia chinensis*, *Prunus fasciculata*, *P. fremontii*, *Acacia greggii*, and *Yucca schidigera*.

The arid eastern escarpments of the Peninsular Ranges between 1,000 and 2,300 meters are covered by open stands of desert chaparral, usually in association with forests of two pinyons, *Pinus quadrifolia* and *P. monophylla*. Common shrubs include various scrub oaks (*Quercus turbinella*, *Q. cornelius-mulleri*, *Q. cedrosensis*), as well as *Rhus ovata*, *Ceanothus greggii*, and leaf-succulents such as *Yucca schidigera*, *Nolina parryi*, and *Agave deserti*.

Closed-cone conifer forest. Forests are scarce in the semiarid landscape of northern Baja California (detailed distributions of tree species in northern Baja California are given in Minnich 1987a). The chaparral belt includes only widely scattered patches of small- to medium-sized coniferous trees, all having the serotinous or partially serotinous closed-cone habit, and most being restricted to higher altitudes of the near-coast ranges. Widely scattered colonies of *Cupressus guadalupensis* var. *forbesii* grow on the near-coast ranges from Tecate to the mountains east of Ensenada and also on the coastal hillsides southwest of San Vicente and foothill summits west of the Sierra San Pedro Mártir. Three clusters of *Pinus attenuata* or knobcone pine occur in the near-coast ranges near Ensenada and Santo Tomás. The closely related *P. muricata* (bishop pine) is found on coastal bluffs west of San Vicente and at Punta San Quintín (Gentry 1949). The partially serotinous *Pinus coulteri* is known from only six localities: one on Sierra Blanca near Valle Guadalupe and the other five from the middle slopes of the Sierras Juárez and San Pedro Mártir. Small forests of *Cupressus arizonica* var. *stephensonii* grow along Cañada el Rincón and adjacent mesas, east of Santa Catarina, in the southern Sierra Juárez (Moran 1977).

Coast live oak woodland and riparian forest. Riparian forests of *Populus fremontii* and *Platanus racemosa* occur along the length of the Pacific coast of northern Baja California. *Populus fremontii* extends eastward along streams and dry arroyos that have near-surface groundwater to the Sonoran Desert, as well as to the Colorado River. The evergreen *Quercus agrifolia* (coast live oak) forms mostly open woodlands along arroyos, margins of basins and occasionally on north-facing slopes. It is most common on the western flank of the northern Sierra Juárez and on the near-coast ranges southward to Santo Tomás. From Santo Tomás, scattered populations extend eastward along the transverse ranges to about Valle la Trinidad, then southward along the western escarpment of the Sierra San Pedro Mártir. *Quercus chrysolepis* (canyon live oak) grows on steep north-facing exposures, along canyons and on cliffs in the upper margins of the chaparral belt, including the highest peaks of the near-coast ranges, the summits rising above the Sierra Juárez plateau, and the upper

mesas of the southern volcanic tablelands. It is widespread in the conifer forests of the Sierra San Pedro Mártir.

Pinyon Forest. The inland Peninsular Ranges above 1,300 meters in elevation contain widespread forests of two pinyon pines, *Pinus quadrifolia* and *P. monophylla*. *P. quadrifolia*, which is typically associated with chamise and red shank chaparral, grows sparingly and usually in small patches on the upper western slope of the Sierra Juárez and between El Alamo and Santa Catarina. Stands are more common but fragmented in the tablelands of the southern Sierra Juárez and along the western slope of the Sierra San Pedro Mártir. Pinyon forests become increasingly continuous and dominance shifts from *P. quadrifolia* to *P. monophylla* as one crosses the crest of the Peninsular Ranges onto the desert escarpment. The increasing continuity of stands is paralleled by a transition in understory vegetation from dense coastal chaparral to open desert chaparral.

Mixed-Conifer Forest. The high elevations of the Peninsular Ranges are covered by Jeffrey pine (*Pinus jeffreyi*) and mixed-conifer forest, the only plant communities in northern Baja California in which tall trees form extensive cover. The pronounced difference in the altitude of the Peninsular Ranges results in prominent contrasts in forest composition and local distribution. The lower, more arid Sierra Juárez above 1,300 meters and the slopes of the Sierra San Pedro Mártir between 1,500 and 2,000 meters are covered by Jeffrey pine. This forest grows mostly in basins, around the margins of meadows, and along arroyos. Above 2,000 meters in the Sierra San Pedro Mártir are extensive, floristically richer mixed-conifer forests that cover hillslopes as well as basin floors and are similar to the mixed-conifer forests of California (Minnich et al. in press). South-facing slopes are covered with *P. jeffreyi* mixed with white fir (*Abies concolor*) and sugar pine (*Pinus lambertiana*). *Abies concolor* and *P. lambertiana* are the dominant trees on steep northern exposures. White fir/sugar pine forests on the upper eastern escarpment contain the endemic mountain cypress (*Cupressus montana*), especially on the rock faces of Picacho del Diablo. Lodgepole pine (*Pinus contorta*) is common near meadows and along arroyos at Vallecitos (mixed lodgepole pine forest). Incense cedar (*Calocedrus decurrens*) is scattered near watercourses and along canyons in both the Sierra San Pedro Mártir and Sierra Juárez. Groves of quaking aspen (*Populus tremuloides*) are found at wet sites throughout the Sierra San Pedro Mártir plateau above 2,300 meters.

Mixed-conifer forests are mostly open and parklike, consisting of mature trees with few pole-size trees and saplings, as well as open shrub cover (Minnich et al. in press). Important shrubs in Jeffrey pine forest are *Arctostaphylos pringlei*, *A. pungens*, *Quercus peninsularis*, *Artemisia tridentata*, and *Salvia pachyphylla*. Mixed conifer forests include *Symphoricarpos parishii*, *Quercus chrysolepis*, and timberland chaparral dominated by *Arctostaphylos patula* and *Ceanothus cordulatus*.

The forest belt contains numerous wet meadows that are the focal point of cattle grazing in summer. Most are relatively small, but several are greater than 500 hectares. Dominant genera include *Juncus* spp. and *Carex* spp., similar to those in meadows in the mountains of California. Other common grasses and herbs include *Poa annua*, *Muhlenbergia richardsonis*, *Ranunculus cymbalaria*, *Epilobium adenocaulon*, *Astragalus gruinus*, *Oenothera*

californica, *Berula erecta*, and *Cirsium foliosum*. Drier or overgrazed meadows are covered by herbaceous perennials such as *Achillea*, *Potentilla*, and *Aster*.

Desertscrub. Desert plant communities in northern Baja California comprise creosote bush scrub and microphyllous woodlands (Peinado et al. 1995a). Creosote bush scrub is dominated by *Larrea tridentata* growing with drought-deciduous subshrubs, such as *Ambrosia dumosa* and *Encelia farinosa*. This type also contains many succulents including *Fouquieria splendens*, *Agave deserti*, and a diversity of prickly pears and chollas (*Opuntia* spp.). Microphyllous trees such as *Olneya tesota*, *Cercidium floridum*, *Prosopis glandulosa* and *Dalea spinosa* grow along arroyos and fan-heads of the Peninsular Ranges, and other bajadas of the Sonoran Desert. Palm oases of *Washingtonia filifera* and *Brahea armata* appear at wet sites in many desert arroyos on the eastern escarpment of the Sierra Juárez, as well as in the coastal and desert flanks of the southern Sierra San Pedro Mártir.

2

EVENTS LEADING TO SPANISH EXPLORATIONS

The vegetation of northern Baja California was first described during a series of Spanish explorations between 1766 and 1796 (Meigs 1935). It was a turbulent time in the history of the California missions, just after control by the Jesuits of the peninsula had been abruptly terminated with their expulsion in 1767. Replacing them with Franciscan and Dominican missionaries, the Spanish crown also sent out directives to the Franciscan missionaries, who replaced the Jesuits, to expand the Spanish sphere of influence northward from the deserts of Baja California to Alta California to impede foreign encroachment. The following brief review of historical events and explorations of northern Baja California is summarized from Bolton 1927; Meigs 1935; Aschmann 1959a; Henderson 1964; Servín 1968; and Tiscareño and Robinson 1969.

The peninsula was first settled by Jesuit missionaries in the eighteenth century, two centuries after the Spanish conquest of México City. Their first mission was founded at Loreto in 1697; 70 years later the Jesuits had established missions as far north as San Borja and explorations had reached the southern margin of northern Baja California at latitude 30° (see Map 7 in Aschmann 1959b). Fray Fernando Consag, who was stationed at San Ignacio and served a term as father visitor for California, conducted several expeditions and wrote general accounts of the northern part of the Central Desert (Servin 1968; Aschmann 1966). In 1746, Consag, along with Don Fernando Rivera y Moncada who later accompanied several Franciscan expeditions from San Fernando Velicatá to San Diego, led a voyage northward along the Sea of Cortez (Gulf of California) to the mouth of the Colorado River. This journey resulted in the first maps of the area, including the first observations by Europeans of the Sierra San Pedro Mártir. Consag readily recognized that the gulf region's desolation would preclude establishment of missions there (Meigs 1935). In 1751, he trekked along the Pacific coast to an area just south of El Rosario. Failing to find a suitable site for a mission near the sea, in 1753 he undertook a second land journey northward through the center of the peninsula to the subsequent mission site of San Fernando Velicatá.

In 1766, Wenceslaus Linck, a minister of the San Borja mission, became the first European to penetrate the more mesic mountain landscapes of northern Baja California (Burrus 1966; Meigs 1935; see Figure 1 and map 3 for routes of the expeditions in northern Baja California). With the goal of exploring the Colorado River, Linck trekked from Mission San Borja to the future mission of San Fernando Velicatá and then to La Cieneguilla at the southern base of the Sierra San Pedro Mártir, a site visited by Franciscan missionaries in

1769. His party then traversed the San Pedro Mártir and travelled along the desert plains at the base of the eastern escarpment to a point near Picacho del Diablo (Tiscareño and Robinson 1969).

In 1768, José de Gálvaz, the King's visitor-general for New Spain, came to Baja California to expel the Jesuits and to reorganize the government and economy. The Franciscan order established its first mission at San Fernando Velicatá. The same year, a royal order was sent to Viceroy Carlos Francisco de Croix and de Gálvaz to resist the aggression of the Russians, who were extending their settlements from Alaska down the Pacific coast (Bolton 1927). de Gálvaz organized a historic expedition from the former Jesuit territory to Alta California to establish garrisons at San Diego and Monterey. Although the Franciscans initially preferred an unbroken chain of missions extending northward from San Fernando Velicatá, Junípero Serra, the father president of the Franciscan missions, soon advocated the establishment a chain of missions in Alta California. Another chain of missions would later be established between San Fernando Velicatá and San Diego.

The Franciscan expeditions in northern Baja California were under the general command of Gaspar de Portolá, governor of the peninsula. The expedition consisted of two separate parties following the same route from San Fernando Velicatá to San Diego. The first party was led by Captain Fernando de Rivera y Moncada between March 24 and May 14, 1769, and was accompanied by Fray Juan Crespi, whose diary gives the most complete account of the journey (Bolton 1927). From the second expedition, led by Captain Gaspar de Portolá between May 15 and July 1, 1769, the most complete diary was written by Junípero Serra (Tibesar 1955). Other diaries, including those of Moncada and Portolá, were brief and contained few observations of the vegetation.

The Franciscans did not follow the easiest route available to them—they often trekked through the mountains, where there were more certain water sources, instead of through the more topographically accessible coastal plains (Bolton 1927; Meigs 1935; Map 1). These expeditions were twice forced from the mountains to the coast. From San Fernando Velicatá (lat. 29°), the parties had closely followed Linck's route to La Cieneguilla in the southern Sierra San Pedro Mártir (Bolton 1927:63,72). The Portolá expeditions then parted ways from the Linck journey to the desert by moving northward along the Pacific coast. The Franciscan parties first traversed the west base of the Sierra San Pedro Mártir until they were forced west by rugged foothills near Valladares to San Telmo. From there, they traveled north near the modern coastal highway and discovered potential mission sites at San Vicente and Santo Tomás. After reaching Cañon la Grulla, which is 40 kilometers south of present-day Ensenada, the parties worked northward through several drainages of the near-coast ranges until another mountain barrier forced them west to the Bahia Todos Santos (Ensenada). The remainder of their journey virtually retraces the modern highway from Ensenada to Valle Guadalupe and the coastal terraces to San Diego.

Once established in Alta California, the Franciscans quickly realized that they had insufficient manpower to establish missions south of San Diego and, furthermore, Dominican leaders desired a share of California. In 1772, a concordat was signed between the viceroy of Mexico and the leaders of the Dominican and Franciscan orders. The Dominicans agreed to take charge of the old Jesuit mission system in Baja California and to develop missions in

the mediterranean lands of the northern peninsula as far as San Diego. The Franciscans had jurisdiction of Alta California from the present international border northward (Meigs 1935).

To facilitate travel and keep open lines of communication between Alta California and the south, the Dominicans established missions along the coast at El Rosario (1774), Santo Domingo (1775), San Vicente (1780), San Miguel (1787), and Santo Tomás (1791). Explorations of the mountainous interior for the purpose of "converting the native population to Christianity," and to provide a route for easy access to the Indians of the Gulf of California was a priority as early as the 1770s (Meigs 1935; Tiscareno and Robinson 1969). For 20 years, however, expeditions to the Sierra Juárez and Sierra San Pedro Mártir were limited; no mission was founded until the 1790s because of difficulties in maintaining the coastal missions due to crop failures and the decimation of Indians by disease (see review by Tiscareño and Robinson 1969). In 1775, José Velazquez, a military officer, crossed the Sierra San Pedro Mártir via El Rosario and San Fernando Velicatá to determine whether there was a suitable port in the northern part of the Gulf of California (Andrés-Zárate 1991). Six years later, Velazquez and Pedro Fages led an expedition from San Vicente to Valle la Trinidad and east to Laguna Salada, then returned via the Laguna Mountains of San Diego County.

In 1791, Fray Crisóstomo Gómez, the Dominican president of Baja California, obtained permission from the Viceroy Conde de Revilla Gigedo to establish missions in the inland mountains, as well as at the lower Colorado River. In 1794, an exploration party was sent out to the Sierra San Pedro Mártir by acting Governor José Joaquin Arrillaga. The next year, the Dominicans established the mission San Pedro Mártir at a "watered forest-rimmed meadow," named Casilepe, which a recent discovery of foundation stones has shown was the northern end of La Grulla meadow (Foster 1992). Casilepe though, proved to be unsuitable due to the area's cold, snowy climate (altitude: 2,100 meters). Soon after, the Dominicans selected a final, more temperate site for the mission at a lower altitude (1,550 meters), about 15 kilometers to the south.

The Dominicans were apparently unaware of José Longinos-Martínez's remarkably detailed account of the range in 1792 because his appearance in the region was unrelated to mission activities (Simpson 1938, 1961). Longinos-Martínez was part of a royal scientific expedition that sent Spanish scientists to New Spain, especially to survey Mexican plants, including those with medicinal properties (Engstrand 1981). His expedition traversed the area from México City through Guadalajara to the port of San Blas. After crossing the Gulf of California to Loreto, he explored the cape region and then journeyed northward through the peninsula into Alta California as far as Monterey. While in northern Baja California, Longinos-Martínez climbed from Mission Santo Domingo to the Sierra San Pedro Mártir, where he visited the three primary mountain meadows, and descended to the eastern escarpment to Linck's route on the desert floor (Simpson 1961; Map 1). He recrossed the highest plateaus of the range on his return to Santo Domingo mission.

Explorations to establish a second interior mission began in 1794 when Governor Arrillaga directed Manual Ruíz and Fray Tomás Valdellon to survey the basins between El Alamo and the prospective mission site of Santa Catarina. In 1795, Fray Idelfonso Bernal also traversed these basins and investigated a wet site on the east side of the plain (apparently

the modern mission site). They left brief accounts with little botanical content (Meigs 1935; Tiscareño and Robinson 1969).

The ultimate decision to establish a mission at Santa Catarina (originally named Santa Catalina by the Dominicans) was based on four extraordinary journeys of northern Baja California undertaken by Arrillaga from August through October of 1796. No other person explored more territory in Baja California during the late eighteenth century.[1] All four expeditions began at Mission San Vicente, his temporary home base (Map 1). The first journey was northeastward across the transverse ranges to Santa Catarina to evaluate whether the surrounding lands were suitable to support a mission there. Arrillaga returned through Valle la Trinidad and turned west to San Vicente. On the second journey, whose purpose was to determine the suitability of San Felipe as a port on the Gulf of California, the expedition crossed the San Pedro Mártir from mission Santo Domingo to present-day San Felipe. The journey took the primary mission trail south from San Vicente to Mission Santo Domingo, then eastward along Cañon Santo Domingo to Mission San Pedro Mártir (Meigs 1935:149). After visiting La Encantada meadow, Arrillaga then descended the sierra along Arroyo el Cajón and crossed the desert to San Felipe. The party then returned to the eastern base of the Sierra San Pedro Mártir and pushed northward to Valle San Matiás, where they headed west to San Vicente via Valle la Trinidad. The third and most remarkable expedition traversed the near-coast ranges, from Cañon La Grulla (south of Ensenada) across the southern margin of Valle Ojos Negros and the Sierra Juárez, to Arroyo Grande in the Sonoran Desert. Arrillaga recrossed the sierra at the pass of Puertezuelo to Santa Catarina, then rode northward along the crest of the range to La Laguna (Laguna Hanson). He then descended the Sierra Juárez to explore the valleys of Ojos Negros and Guadalupe and then returned to San Vicente. On his last journey, he departed eastward from San Vicente through Santa Catarina and Puertezuelo to the Colorado River. The party skirted northward along the east base of the Sierra Juárez to the present international boundary before returning through the Laguna Mountains to Mission San Diego, and then back to San Vicente.

The distance covered by these explorers is extraordinary, approximately 1,500 kilometers, considering the primitive state of travel through lands unknown and having only aboriginal paths (Table 2). Journeys through precipitous country sometimes caused injury to animals and to the diarists themselves. The expeditions of Linck, Serra, and Crespi were delayed by the logistics of moving large parties and livestock. Almost daily, native Americans accompanying these explorations died from introduced European diseases. Yet, the Linck and Crespi/Serra expeditions traversed nearly 500 kilometers of territory. Longinos-Martínez and Arrillaga led smaller parties on horseback over greater distances. Longinos-Martínez's journey from Mission Santo Domingo to the Sierra San Pedro Mártir covered 173 kilometers in a week, and Arrillaga's four journeys traversed 862 kilometers on the northern peninsula. Together these journeys crossed nearly every ecosystem in the region, providing extraordinary regional detail on the species composition and distribution of each.

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[1]Arrillaga's career leading to his expeditions is detailed by Tiscareño and Robinson (1969).

Table 2. The distances covered by eighteenth-century Spanish journeys in northern Baja California

Expedition	Distance (km)
Linck, Crespi, Serra	76
Linck	75
Crespi, Serra	311
Longinos-Martínez	173
Arrillaga (first journey)	169
Arrillaga (second journey)	170
Arrillaga (third journey)	315
Arrillaga (fourth journey)	208
TOTAL	1,497

Source: Estimated by overlay of expedition routes on DETENAL topographic maps.

INTERPRETING SPANISH DIARIES

The content of the Spanish diaries depended upon the duties of the journalists. The Franciscan and Dominican missionaries wrote diaries for submission to the viceroy to determine whether local resources met the standards necessary to establish a mission. The resources required included potable water, fuelwood, timber for construction, stone and other building supplies for construction of missions, as well as a sufficient number of Indians for conversion (Meigs 1935:20). Longinos-Martinez's efforts focused on the natural history of México (Engstrand 1981).

The value of the descriptions of vegetation and flora in the diaries depends upon the accurate relocation of daily entries. Statements concerning the vegetation often do not refer to fixed sites but rather to a general district or are a summary of the day's route. We avoided the literal interpretation of quantitative data—latitude measurements, compass directions, and

distances traveled, usually in leagues;[2] for instance, the latitude measurements of Crespi are consistently one half degree too far north (Table 3). Aschmann (1966) found a similar error in Consag's measurements. Our approach was to fit landscape descriptions with the surrounding terrain (Minnich 1988), utilizing our field experience, modern DETENAL topographic maps (INEGI, Mexico, Aguascalientes, scale: 1:50,000), and aerial photographs. Accounts of terrain sometimes yield unique evidence of specific locations—such as the junction of two arroyos, the presence of hot springs, or an unusual rock outcrop. Place-names are particularly valuable if they are in current use or are reconstructible historically. A surprisingly high proportion of the names given by the diarists has survived. Quantitative data still have value. For instance, the consistency of errors in latitude measurements by Crespi makes his estimate of latitude a reliable guide to the locations along his route.

Crespi's detailed directions and use of place-names permit an accurate reconstruction of the entire route of the Franciscan journeys (Meigs 1935). Fortunately, Crespi and Serra exchanged notes at the end of their treks in San Diego, in particular the new place-names they ascribed to specific localities. Serra's sense of place and compass bearings was often ambiguous; however, the entry of place-names of both diarists to the same locations permitted us to locate Serra's accounts under Crespi's directions. The routes taken by Arrillaga were easier to follow than those of the earlier expeditions because most place-names had developed common usage after 25 years of mission activity.

With few exceptions, we believe the routes of Linck (Burrus 1966), Crespi and Serra (Meigs 1935), and Arrillaga (Tiscareño and Robinson 1969) have been accurately reconstructed, and specific accounts can be located within 5 kilometers resolution; however, we have retraced routes or propose new interpretations of existing ones in several areas that we believe were inaccurately located or were unknown to these authors. For example, Simpson's annotations (1961) provide little detail on the route of Longinos-Martínez through the Sierra San Pedro Mártir. We believe his reconnaissance can be retraced from his compass directions, place-names, and descriptions of the terrain, providing a single bearing is assumed to be in error. The reader must also assume that the lake in the range that he saw was ephemeral. We also reconstructed Arrillaga's descent along the west slope of the Sierra Juárez from Laguna Hanson to Valle Ojos Negros (see Tiscareño and Robinson 1969).

EIGHTEENTH-CENTURY SPANISH "BOTANY"

The diaries require an understanding of eighteenth-century botanical vocabulary because the descriptions of vegetation lack the sophistication of modern science. Hence, the success in "reading" these journals depends on interpreting plant names and consulting original Spanish texts. An analysis of these accounts results in an appreciation of a fundamental characteristic of the journals: the diary entries are mostly floristic statements, often the simple listing of

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[2]The formal Spanish league is 5,000 varas (one vara is about 33 inches or 0.9 meters) or 2.64 statute miles (4 kilometers; Simpson 1961:103). However, a league is estimated as an hour's ride on a horse, and this length tends to vary from 2.5 to 5.0 kilometers in the difficult terrain of northern Baja California (Meigs 1935:149).

Table 3. Crespi's latitudes and corrections between San Fernando Velicatá and San Diego

Location	Crespi's latitude	Actual latitude	Difference
San Juan de Diós	30° 46'	30° 09'	37'
Arroyo San Miguel/Rancho San Antonio	30° 50'	30° 16'	34'
Cieneguilla	30° 56'	30° 32'	24'
San Isidoro	31° 05'	30° 46'	19'
Rancho San Antonio	31° 08'	30° 48'	20'
East end of Valle San Telmo	31° 17'	30° 56'	21'
San Telmo	31° 11'	30° 58'	13'
San Vicente	32° 00'	31° 20'	20'
Santo Tomás	32° 10'	31° 33'	23'
Near Ensenada	32° 14'	31° 52'	22'
Western Valle Guadalupe	32° 18'	32° 00'	18'

Source: Tiscareño and Robinson, 1969.

species encountered. Although plants were being classified systematically for the first time in Europe, the formal taxonomic nomenclature of Linnaeus was employed only by Longinos-Martínez (Engstrand 1981). The other explorers used Spanish common names, but many of these are in current use and can be identified as to genus and, occasionally, as to species (see Martínez 1947:149-154; Roberts 1989; Tiscareño and Robinson 1969:100-101).

With the exception of Serra, the diarists had an excellent botanical vocabulary of the Sonoran Desert flora. This background is doubtless based upon their predecessors' work and upon their personal experience with these ecosystems in semiarid areas of mainland México and Baja California. Identifications were most precise among ethnobotanical plants, such as **mescal** (*Agave* spp.), **jojoba** (*Simmondsia chinensis*), **pitahaya dulce** (*Lamaireocereus thurberi*), and **pitahaya agria** (*Machaerocereus gummosus*) (see Aschmann 1959b, 1966). Linck's daily entries provide little information on desert vegetation but instead focus on riparian plants near waterholes. He does summarize geographic information on the distributions of several desert species at the end of his diary. The diarists also readily recognized trees and shrubs that are congeneric to Europe, such as **sauce** (*Salix*), **alamo** (*Populus*), **encino** (*Quercus*), and **pino** or **piñon** (*Pinus*). They also readily recognized taxa

with unique or bizarre morphologies, such as palms or **cirio** (*Fouquieria columnaris*). A few plant names were mistranslated. For example, **aliso** was conventionally interpreted as *Alnus* rather than as *Platanus racemosa*.

In contrast, the mediterranean-climate vegetation was almost entirely alien to the early missionaries. Indeed, the diarists often stated they encountered species never seen before. Although the vegetation of Old Spain and California are morphologically similar, there is almost nothing in common at the species level, and little at the genus level. In the chaparral only scrub oaks (*Quercus* spp.) were identified. Without the experience in Californian mediterranean vegetation that they had for the Central Desert, the Spanish explorers resorted to using morphological analogues from the Old World. *Adenostoma fasciculatum* was apparently referred to as rosemary by Serra and Longinos-Martínez because of the similarity of foliage. They also borrowed generic structural terms applied to other plant communities in Mexico, such as **chamiso** (thicket) (Martinez 1947; see glossary of English and Spanish common names given in Appendix A).[3]

The language in journal descriptions on plant cover or structural characteristics of the vegetation is highly informal and vague. The most important structural term used by the diarists is **pasto** (pasture). Although this term has been generically translated to grassland, it is really a cultural term that relates to forage for livestock. It can be more definitively interpreted as "herbaceous cover," inasmuch as we have no firsthand evidence whether nonwoody vegetation consisted of grasses or forbs. Other descriptions of vegetation structure relied upon qualifiers of the language. Deserts were "sterile," which may be an antonym for pasture. Chaparral was described as "hillslopes dotted with little trees," and maritime desert scrub was "crowded with **mescales**." By Arrillaga's time, a vocabulary had evolved for the chaparral: **Chamizo** was used to describe brush dominated by *Adenostoma fasciculatum* (chamise), and **madroño** for *Arctostaphylos*-dominated chaparral. The term **pino** can imply a pine forest, not just pines.

The diarists tended to emphasize forests and grasslands—in anticipation of lumber and a potential livestock economy. Thus, except for the writings of Arrillaga, descriptions of chaparral and other shrublands are all too scarce.

Although the Spaniards did not emphasize plant community structure, we can credibly infer the vegetation structure from the species composition, based upon species relationships to communities seen presently. It is recognized that individual taxa form temporal associations over long periods, because species migrations operate independently of one another (Davis 1981; Davis and Botkin 1985); however, over the relatively short time of two centuries, we assume that species associations are relatively stable. Thus, an observation of

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[3] In current practice, Spanish names for desert plants continue to be used in the United States. With few exceptions, the names of temperate species have become unfamiliar to English speakers (see glossary in Appendix A). As a consequence, in the text we use Spanish names for subtropical desert species and English names for temperate species that are congeneric with those in Europe, mostly in chaparral, conifer forests, and riparian forests. Spanish names for temperate species will be given in braces. All Spanish names are given in boldface type.

Fouquiera columnaris is evidence for the presence of central desert vegetation. Similarly, **chamizo** and **madroño** may be linked with chaparral.

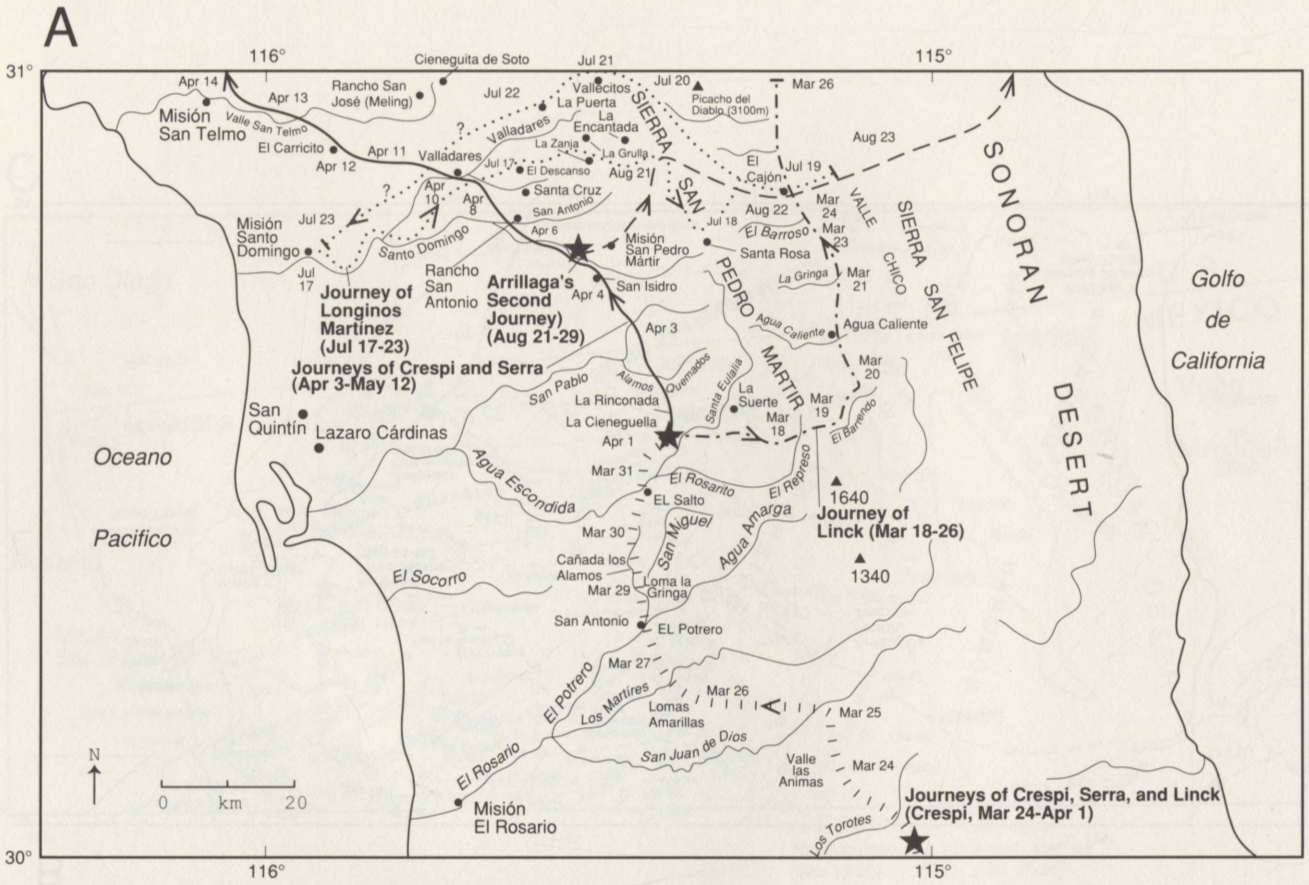
Our review of these documents shows that the Spanish explorers were educated, excellent observers. This can be seen in the precision of their species-level identifications in desertscrub communities, for which they had developed formal knowledge in their efforts elsewhere in the deserts of the mainland and Baja California. The ambiguity in their accounts of mediterranean scrublands in northern Baja California is related to their unfamiliarity with vegetation rather than to their observation skills.

LATE NINETEENTH-CENTURY SURVEYS

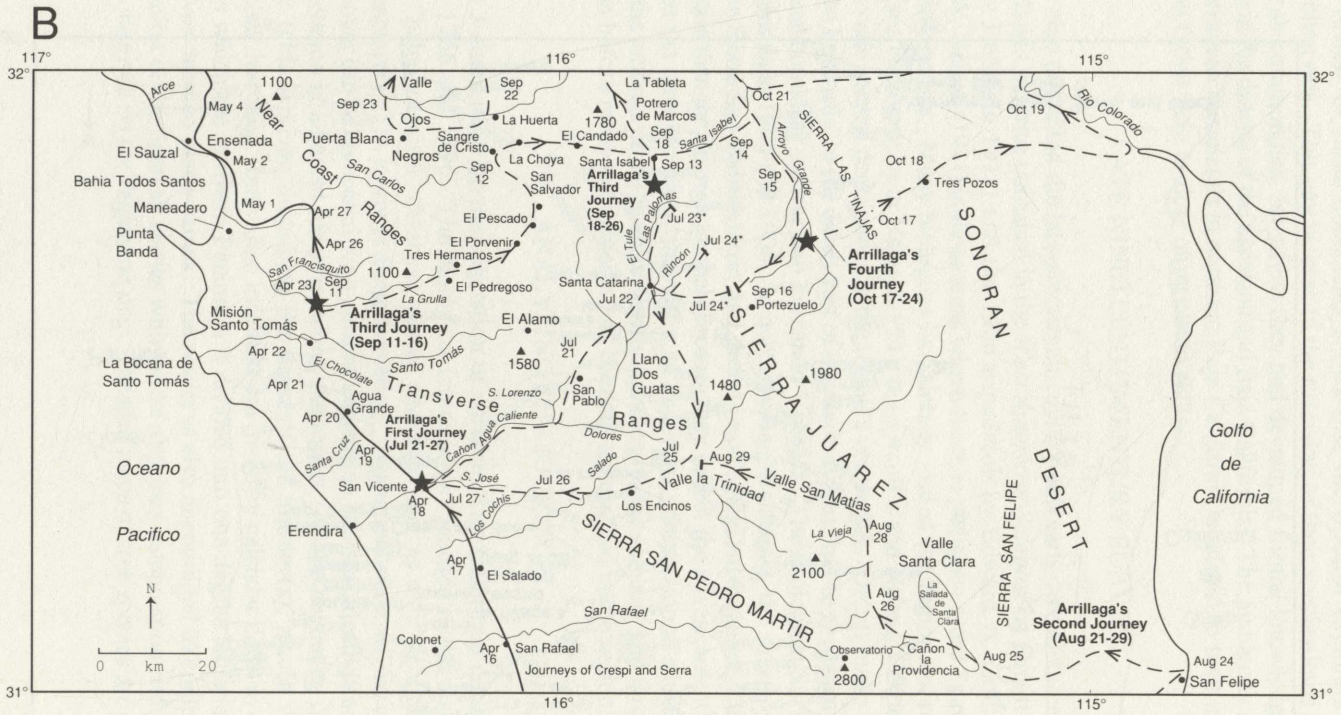
We have also consulted the late-nineteenth-century and early-twentieth-century surveys of northern Baja California published in the *West American Scientist* by Orcutt (1883, 1886a,b, 1889; see DuShane 1971) and the 1906 expedition by Edward A. Goldman (1916) and Edward W. Nelson (1921) in those areas where these expeditions cross Spanish explorations of a century before. Many biologists had already visited the region during the nineteenth century (see bibliography in Nelson 1921), but Orcutt's and Nelson's expeditions were the first to provide general descriptions of the region's vegetation. Orcutt made several botanical journeys to Ensenada, to the desert east of the Sierra Juárez, and to the coastal areas from the international boundary to near San Fernando Velicatá. The Biological Survey traversed the entire peninsula in 1905 and 1906. In northern Baja California, the survey visited the Sierra Juárez, the Sierra San Pedro Mártir, and deserts east of the latter range. These accounts are more precise than the Spanish journals because they reflect the advancement of the biological sciences at the time; however, they offer an important comparison at a historical midstream between the writings of the Spanish diarists and the present. Nelson and Orcutt also describe the region before many exotic herbs had become widespread in the region.

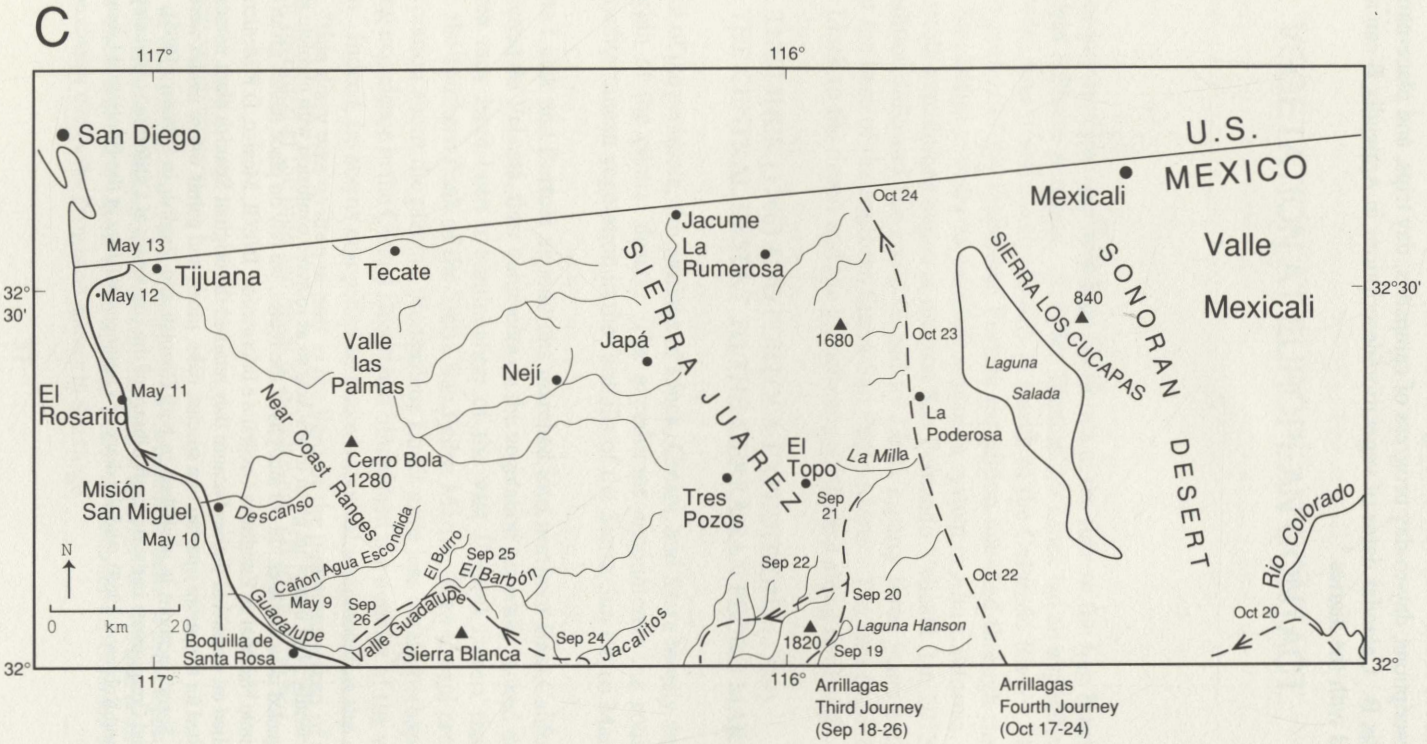
ANALYZING THE JOURNEYS

Chapters 3 and 4 describe the vegetation of northern Baja California during eight journeys between 1766 and 1796. The biological information recorded in the diaries represent, in effect, a "paleobotanical" database of two centuries ago, as seen through the eyes of the Spanish explorers. The journeys are presented as "vegetation traverses" so that cited records of plant cover can be compared with current vegetation site-specifically, and for comparison with vegetation at adjacent localities along the routes. At the beginning of each journey, a summary table is given describing the dates of the journey(s), places visited, and plant communities described. Individual localities are given by calendar dates in detailed maps on Map 2, in which the northern Peninsula is divided into one degree latitude segments. Map 2 also gives detailed place-names. The reader is also encouraged to compare the accounts of vegetation in the Spanish diaries with modern species composition and plant community distributions given on the vegetation map. Detailed maps of tree species are given in Minnich (1987a).



Map 2. Detailed maps of eighteenth-century Spanish explorations and place names: (A) latitude 30°N to 31°N; (B) latitude 31°N to 32°N, and (C) north of latitude 32°N.


B
117°
116°
115°
32°
31°
Arce
May 4
1100
Near
Sep 23
Valle
Sep 22
La Tableta
Oct 21
Oct 19
Rio Colorado
Ojos
La Huerta
1780
Potrero de Marcos
Sep 18
Santa Isabel
Arroyo Grande
SIERRA LAS TINAJAS
Ensenada
Puerta Blanca
Sangre de Cristo
El Candado
Sep 14
El Sauzal
May 2
Negros
La Choya
Santa Isabel
Sep 13
Sep 12
Arrillaga's Third Journey (Sep 18-26)
Sep 15
Oct 18
Tres Pozos
Bahia Todos Santos
Coast
San Carlos
San Salvador
Maneadero
May 1
Apr 27
Ranges
El Pescado
Jul 23*
Las Palomas
El Tule
Oct 17
Punta Banda
Apr 26
El Porvenir
Jul 24*
Rincon
Arrillaga's Fourth Journey (Oct 17-24)
SONORAN
San Francisquito
Tres Hermanos
Apr 23
Sep 11
1100
El Pedregoso
Santa Catarina
Jul 22
Jul 24*
Sep 16
Portezuelo
La Grulla
Misión Santo Tomás
Arrillaga's Third Journey (Sep 11-16)
El Alamo
Jul 21
1580
SIERRA JUAREZ
Apr 22
El Chocolate
Santo Tomás
Llano Dos Guatas
1480
1980
La Bocana de Santo Tomás
Apr 21
Transverse
S. Lorenzo
San Pablo
Agua Caliente
Apr 20
Agua Grande
Arrillaga's First Journey (Jul 21-27)
Ranges
Dolores
Golfo de California
Cañon Agua
Santa Cruz
Apr 19
Jul 25
Aug 29
Oceano
Pacifico
S. José
Jul 26
Salado
Valle la Trinidad
Valle San Matias
San Vicente
Apr 18
Jul 27
Los Cochis
Los Encinos
SIERRA SAN FELIPE
DESERT
Erendira
La Vieja
Aug 28
Valle Santa Clara
SIERRA SAN PEDRO MARTIR
Apr 17
El Salado
2100
La Salada de Santa Clara
Aug 26
San Rafael
Arrillaga's Second Journey (Aug 21-29)
Colonet
Apr 16
San Rafael
Observatorio
2800
Cañon la Providencia
Aug 25
Aug 24
San Felipe
Journeys of Crespi and Serra
N
0 km 20


C
117°
116°
San Diego
U.S.
MEXICO
Mexicali
Valle
Mexicali
Jacume
La
Rumerosa
Oct 24
May 13
Tijuana
Tecate
SIERRA JUAREZ
SIERRA LOS CUCAPAS
SONORAN DESERT
32°30'
32°
30'
May 12
840
1680
Oct 23
Valle
las
Palmas
Nejí
Japá
Laguna
Salada
El
Rosarito
May 11
La
Poderosa
Near Coast Ranges
Cerro Bola
1280
El
Topo
La Milla
Misión
San Miguel
Descanso
Tres
Pozos
Sep
21
May 10
N
Cañon Agua Escondida
El Burro
Sep 25
El Barbón
Sep 22
Oct 22
Río Colorado
0 km 20
May 9
Sep
26
Guadalupe
Valle Guadalupe
Sep 20
Oct 20
Boquilla de
Santa Rosa
Sierra Blanca
Sep 24
Jacalitos
1820
Laguna Hanson
Sep 19
32°
117°
116°
Arrillagas
Third Journey
(Sep 18-26)
Arrillagas
Fourth Journey
(Oct 17-24)

So that the reader may consult original sources, detailed coordinate data on locations of specific descriptions, day-to-day progress of campsites, day trips, and place-names are given in Appendix B. Calendar dates of vegetation descriptions in Appendix B can also be cross-referenced with the diaries.[4]

[4] Modern scientific plant names are given in brackets so as to avoid confusion with obsolete scientific names, which are quoted in parentheses. In our analysis of the routes, we rely on place names given on topographic sheets (Instituto Nacional de Estadistica Geografía e Informatica, INEGI, Mexico, D.F.Mexíco). For the most part, we relied on translated diaries because they retained the original Spanish plant names. Spanish texts were consulted for temperate riparian tree species, oaks, pines, and palms whose names were translated into English. Serra's account is published in both Spanish and English in Tibesar (1955). The diaries of Arrillaga and Crespi reside in the Bancroft Library of the University of California at Berkeley (Bolton, 1927; Tiscareño and Robinson 1969), and the diary of Longinos-Martínez at the Huntingon Library, San Marino, California.

3

VEGETATION AT EUROPEAN CONTACT

The two major journeys into northern Baja California at the time of the first European land explorations had different purposes. In 1766, Wenceslaus Linck led an expedition into the Sierra San Pedro Mártir and nearby deserts in search of the Colorado River. Three years later, the two parties of the Franciscan Portolá expedition marched through the northern peninsula to San Diego in order to establish a mission system in Alta California. Both the Linck and Portolá expeditions began at mission San Fernando Velicatá (lat. 29°N) and the Portolá expedition followed the route blazed by Linck's party three years earlier to La Cieneguilla at the base of the southern Sierra San Pedro Mártir. The two expeditions then parted ways: Linck to the desert and the Franciscans northward along the Pacific coast.[1]

THE LINCK (1766) AND PORTOLA EXPEDITIONS (1769) FROM THE CENTRAL DESERT TO THE SIERRA SAN PEDRO MARTIR

In this segment of the peninsula, the writings of Linck, Crespi, and Serra mostly describe the northern margin of the central desert. The expeditions encountered the southernmost outposts of mediterranean vegetation in the foothills of the Sierra San Pedro Mártir (Table 4; Map 2A).

When the Linck and Portolá expeditions marched into northern Baja California from mission San Fernando Velicatá, their comments on the vegetation generally lacked detail. For them, the area may have been a continuation of the vast Central Desert that extends northward to the southern flank of the Sierra San Pedro Mártir. Juan Crespi provided the greatest information about the plants. Wenceslaus Linck gave less detail, perhaps because his already long experience in the Central Desert had diminished the novelty of the vegetation in this region. Indeed, he seems compelled to make botanical statements at the end of his diary, stating, "this diary was written in part in the light of the questions asked of us, and in part it was not recorded at the time and place of occurrence" (Burrus 1966:86).

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[1]In this chapter, we will first describe both expeditions to La Cieneguilla together to avoid repeating the site descriptions and to permit their comparison at specific locations or districts. We will then describe Linck's crossing of the Sierra San Pedro Mártir to the Sonoran Desert in search for the Colorado River. The remainder of the chapter details the Franciscan journey to San Diego.

Table 4. Summary of vegetation descriptions by Linck (1766), Crespi (1769), and Serra (1769) from San Fernando Velicatá to the southern Sierra San Pedro Mártir

Dates of Journeys[1]	Traverse Segment	Vegetation described
March 23-25 (Crespi) May 15-16 (Serra) March 8-9 (Linck)	San Fernando Velicatá to San Juan de Diós	Desertscrub
March 26-29 (Crespi) May 21-23 (Serra) March 10-11 (Linck)	San Juan de Diós to Loma la Gringa	Desertscrub, palm oases
March 30/April 1 (Crespi) May 24-27 (Serra) March 12-14 (Linck)	Loma la Gringa to La Cieneguilla	Desertscrub, palm oases, riparian forest, desert chaparral

[1] For detailed route information, including place-names and latitude/ longitude coordinate data, see Map 2A and Appendix B.

Upon leaving San Fernando Velicatá, the expeditions went northeast "between some hills" arriving in a dry arroyo which had some grass [Los Torotes]. Crespi best captures the ambience of the Central Desert: "The country continues like the rest of [Baja] California, sterile, arid, lacking grass and water, and abounding in stones and thorns." In a plain that was one league to the north, Crespi found "grass in some places" but the "scarcity of the land continued," and he saw trees called "**cirios** [*Fouquieria columnaris*] and **cocobas**" [**jojoba**, *Simmondsia chinensis*], both common species in the area (Plate 1).

The parties descended a steep slope to an arroyo that Linck named San Juan de Diós, its modern name. The Spanish friars remarked that the stream bed contained many reeds [**caña**, *Phragmites* ?], willow [**sauce**, *Salix*], poplars (**alamo**, *Populus fremontii*), and sycamore (**aliso**, *Platanus racemosa*).[2] *Platanus racemosa* is presently not known from this arroyo, although botanical collections show the southern limit of this tree near El Socorro, 40 kilometers to the west-northwest (Minnich 1987a).

[2] *Alnus rhombifolia*, the only significant member of this genus on the Pacific coast south of Eureka, occurs along streams in Alta California as far south as Mount Cuyamaca (Griffin and Critchfield 1976). It is not known from northern Baja California (Minnich 1987a). **Aliso** customarily translates to "alder," but also refers to *Platanus* spp. Bolton (1927) translates it both "alder" and "sycamore." From our observations, "aliso" in northern Baja California consistently refers to areas of *Platanus racemosa* (Minnich, 1987a: Figure 12 ; cf. Nelson 1921:104).

From San Juan de Diós, the expeditions veered to the west to avoid the peaks of the high Sierra San Pedro Mártir. According to Linck (Burrus 1966:60, 62), the descent from the sierra to the Pacific coast (presumably toward El Rosario) was "much too circuitous to enable us to explore the Colorado River" (they would have to travel too far west to reach their destination); however, they discovered "good road to travel along a strip of land which lies between the sierra and a low area that extends to the coast." This strip includes a series of basins that extend from the arroyo San Juan de Diós to the arroyo of Los Mártires, then northward to El Salto and La Cieneguilla, 50 kilometers to the north (Meigs 1935; Map 2A).

The Spaniards pressed through desertscrub, with riparian vegetation along watercourses. While crossing westward into the Los Mártires drainage, Crespi saw "cacti, very spiny **choyas**" [cylindropuntias, *Opuntia prolifera* or possibly *O. cholla*], as well as the "sad" **cirio** and **cocobas**. The **cirio** and **cacti** were seen and noted again between the arroyos of Los Mártires and El Potrero (Plate 2). The **mescal** [**maguey**, *Agave shawii*] was doubtless abundant here because it was the primary food of the native populations (Aschmann 1959b). In his diary summary, Linck stated that "one continues to find mescal," and the missionaries regaled (feasted) on this plant with the Indians at several camps between San Fernando Velicatá and La Cieneguilla. Much later in his diary, Crespi (April 11, 1769) stated that the **cocoba** was observed during his marches through these basins.

Linck made several comments on the general distribution of desert taxa between San Fernando Velicatá and Los Mártires (Burrus 1966:87): "Occasional sour **pitahayas** [*Machaerocereus gummosus*] were observed, but the sweet **pitahaya** [*Lemaireocereus thurberi*], an important aboriginal food source, disappears before one reaches San Luís," which was 150 kilometers to the south in central Baja California.[3] Linck also made a passing reference to the medesa tree [*Cercidium floridum*].

The desert vegetation in this area was described in 1886 by Orcutt (1886a:58), while on a trek to El Rosario and San Fernando Velicatá from the north:

> The country began to show unmistakable desert characteristics. Four or five unfamiliar species of chollas (Opuntias) were found. Echinocactus Emoryi were...found to be eight feet from the base to the summit of the stem. Giant columnar cactuses, Cereus Pringlei [*Pachycereus pringlei*], stood out prominently on every side, some as much as thirty feet in height, and other cactuses like the cordwood cactus, the cochal [*Myrtillocactus cochal*], Schott's cereus, etc., were in abundance. The wild date or "datiles," a giant yucca some thirty feet in height [*Yucca valida*]...here makes its most northern appearance in the peninsula. [The present northern limit of *Y. valida* is near El Rosario.]

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[3]Wiggins (1980) states that *Machaerocereus gummosus* and *Lemaireocereus thurberi* reach northward on the gulf side to the eastern escarpment of the Sierra San Pedro Mártir and along the Pacific coast to near Colonet. Linck's inland trek apparently bypassed coastal *L. thurberi* populations north of San Luis. Northern outposts of *M. gummosus* occur on coastal bluffs near Ensenada (Wiggins 1980).

He also found "the cirio [*Fouquieria columnaris*]...in greatest abundance, as well as the Ocotillo [*Fouquieria splendens*]." Nelson (1921) described the region in 1906 as having "plentiful growth of the strange **cirio**, giant cactus [*Pachycereus pringlei*], **ocotillo**, and other desert plants—a striking contrast to the scanty vegetation on the barren hills a few miles nearer the coast."

Crespi and Linck recorded that palm trees {**palma**} occurred in the arroyo of El Potrero near Rancho San Antonio. The palms of northern Baja California were admired by Spanish explorers because of the unique morphology and greenery they provided to the surrounding desert landscape.[4] The palms at El Potrero were the first to be noted by the Spaniards between this site and Santa Inés (Cataviñá), 100 kilometers to the south. Aerial photographs show an oasis a short distance upstream from there. Palms were also observed by all three diarists near the junction of the arroyo of San Miguel and Cañada los Alamos. The species of palm was never identified: however, Linck (Burrus 1966) suggested that the explorers had seen *Brahea armata* (blue fan palm): "after leaving San Luís, two kinds of palm trees can be distinguished." One species was "ashen-colored" [*B. armata*] and was seen in the northern part of his expedition, i.e., near the southern Sierra San Pedro Mártir. The other was described as "green-colored, tall, and used for various purposes [*Washingtonia robusta*], but was found only in the south" (in the Central Desert).[5] In 1775, Velasquez also noted palms in the vicinity of San Fernando Velicatá during his march toward the Sierra San Pedro Mártir (Andrés-Zárate 1991). Much later, Orcutt (1886b:56) saw *Brahea armata* near Santa Maria. Today *B. armata* oases are most abundant in the dissected canyons draining the southern Sierra San Pedro Mártir, as described by Wiggins (1944), and remain frequent along the arroyos descending westward toward the coast, in the vicinity of the routes of Linck, Crespi, and Serra (Plate 3, Map 3). Palms are rare along what was Orcutt's route on the immediate coast.

The Spanish missionaries described pasture (**pasto**) along several arroyos and on some of the plains, such as at Valle las Animas (Crespi) and at El Potrero (Serra), and Valesquez saw pasture near San Fernando Velicatá (Andrés-Zárate 1991). It is uncertain whether these accounts refer to grasses or wildflowers. Crespi and Linck passed through the region in March when dicot annuals are likely to be in flower. Serra traversed the area in May, after the flowering season.

Orcutt (1886a,b), passing El Socorro, El Rosario, and San Fernando Velicatá, described extensive fields of wildflowers, such species as "chorizanthe fimbriate [*Chorizanthe fimbriata*], C. procumbens, chorizanthe lastarriaea [*C. coriacea*], calandrinia maritima [*Caliandra maritima*], various krynitzkias [*Cryptantha* spp.], a perityle [*Perityle emoryi*], Astragalus hornii [*Astragalus* spp.], Oenothera crassifolia [*Camissonia crassifolia*], Biscutella californica [*Dithyrea californica*], a hosackia [*Lotus* spp.], the yellow poppy [*Eschscholzia*

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[4]The trees also indicate evidence of surface water so scarce to the region. Thus, observations of palms were routine, and a fairly complete picture of their distributions is provided in the diaries.

[5] *Washingtonia robusta* has been widely planted in northern Baja California, but it is native only to central Baja California from Cataviñá to Bahía de los Angeles and on Isla Angel de la Guarda (Wiggins 1980).



Plate 1. Desertscrub 25 km southeast of El Rosario. Tall *Pachycereus pringlei* (*right*) and scattered *Machaerocereus gummosus* grow with low cover of mostly *Ambrosia chenopodifolia* and *Agave shawii*. Crespi wrote that this area is like the rest of Baja California, "sterile, arid, lacking grass and water, and abounding in stones and thorns." Photograph by Robert Thorne.



Plate 2. View north toward the southern Sierra San Pedro Mártir. Desertscrub with tall *Fouquieria columnaris* grow above understory of *Opuntia* spp., *Agave shawii*, *Viguiera laciniata*, and *Ambrosia chenopodifolia*. Photograph by Harold Berninger.

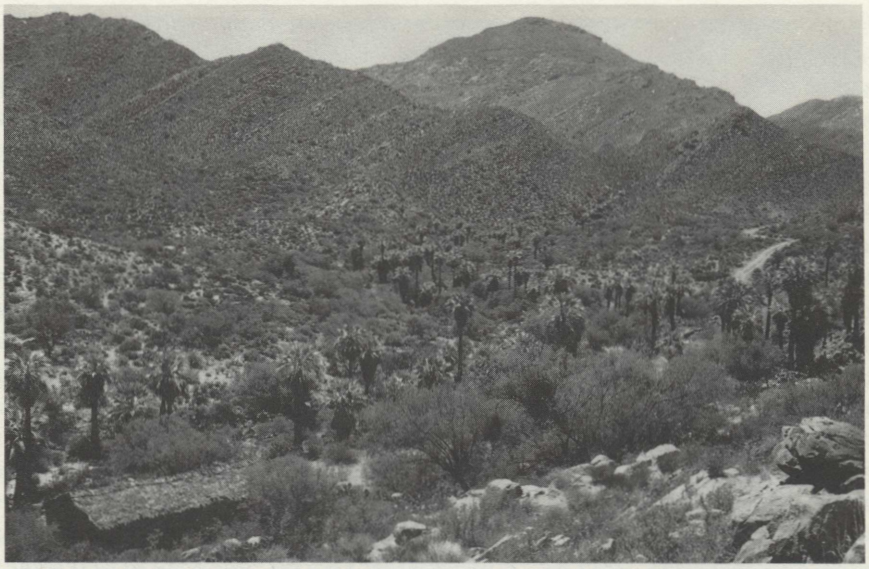


Plate 3. *Brahea armata* oasis at El Palmarito, near La Suerte, in the southern Sierra San Pedro Mártir. Photograph by Robert Thorne.

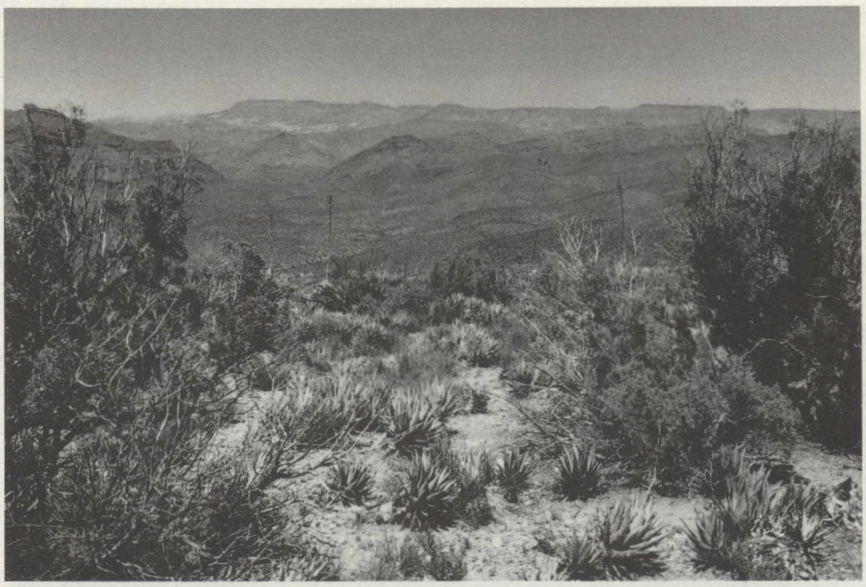


Plate 4. *Juniperus californica* near San Miguel in the southern Sierra San Pedro Mártir. Crespi, Serra, and Linck reported a new "cypress," presumably this tree species, on their way to El Salto. Numerous *Agave shawii* grow with the junipers. Photograph by Robert Thorne.

spp.], primrose [*Oenothera, Camissonia*?], layia elegans [*Layia platyglossa*], and abronia umbellata [possibly *Abronia villosa*]" (modern species names provided by Andrew Sanders, personal communication). Orcutt mentioned that one introduced species, "alfilleria" [*Erodium cicutarium*], occurred there but it was "too scattered to be good feed"; however, at San Quintín he wrote that "the pasture was exactly like that of Alta California: alfilleria [*Erodium cicutarium*], alfalfa [*Trifolium* spp. ?], burr [*Medicago polymorpha*] and red clovers [*Trifolium* spp.] make [up] the greater part of the forage plants" (Orcutt 1886a:41).

The Spanish missionaries recorded the disappearance of several desert species as they ascended the south flank of the Sierra San Pedro Mártir. Crespi, on March 30, 1769, specifically remarked that upon arriving at camp along the arroyo of San Miguel, they "left the cirios behind." This statement fits the modern northern limit of *Fouquieria columnaris*, except for a population 10 kilometers west-northwest near the present-day ranch of El Agua Escondida. No specific statement was made on the limit of cardón [*Pachycereus pringlei*], which presently occurs as far north as near Loma la Gringa; however, Linck stated that "the cardón beyond San Luis does not disappear until one reaches the sierra [San Pedro Mártir]." More than a century later, Orcutt (1886b:56) first encountered cardón nearby at Santa Maria. Nelson (1921:24) saw his first cardón 8 miles (14 kilometers) east of El Rosario and "18 miles (30 kilometers) out..., appeared the first of the singular, polelike tree (*Idria columnaris*) [*Fouquieria columnaris*]." The northernmost populations of *Pachycereus pringlei* on the Pacific slope of the Sierra San Pedro Mártir on aerial photographs are at El Agua Escondida and Arroyo San Miguel.

Linck, Crespi, and Serra hinted at a transition from desert to mediterranean vegetation to the north of this basin. Approaching El Salto, all three writers appeared to recognize *Juniperus californica*. Crespi noted "some change in the land, for although its sterility continued, yet I saw during the day some little trees with leaves similar to the cypress" {**ciprés**}. Serra observed that, "the country became more pleasant and agreeable than before, with a variety of tall and leafy trees. Their branches and leaves resemble a cypress," and Linck stated that "from this vantage point one can see a lovely sierra completely covered with trees from its summit to its lowest slopes. Among the trees we could not identify is one called '**Tascatí**' by the inhabitants of the other side" (the east side of the Sierra San Pedro Mártir, or possibly the Mexican mainland; see footnote 49 in Burrus [1966]). The southern limit of *Juniperus californica*, which still retains the name **tascale** (Roberts 1989), is near Mesa Uribe (30°20' N, 115°05' W; Plate 4). The explorers may also have described *Adenostoma sparsifolium* with its plumed, shaggy appearance and needlelike foliage. The southernmost locality of this shrub is at Rancho San Miguel (30°25' N, 115°20' W). The trees described by Linck as covering the slopes of a "lovely sierra" are pinyon forests that he later encountered in his traverse across the southern Sierra San Pedro Mártir.

The transition between mediterranean vegetation and Central Desert scrub transition was also described by Orcutt and Nelson. Describing the hills toward the coast, Orcutt (1886a:41), recorded that: "the belt from here [San Quintín] to [El] Rosario may be laid down as the dividing line between the semitropical floras of the lower peninsula and the more northern vegetation of Upper California. Many species of cactus disappear soon after leaving Rosario [going north]....We had noticed for more than a week [of travel] one after another

of our old northern friends [mediterranean species] coming in, first scattered, stunted...but gradually increasing in size and number [and] supplanting their southern neighbors." This change in vegetation was also observed by the Biological Survey. Using Merriam's life zone terminology, Nelson (1921:124) noted that "the lower Sonoran zone [desertscrub of the Central Desert, as well as the Colorado and Mojave Deserts] meets the upper Sonoran area [mediterranean scrub] near El Rosario River." He further stated that "there is another Upper Sonoran [mediterranean scrub] strip at the west base of the southern end of [the] San Pedro Mártir Mountains extending south from San Antonio Ranch [Mesa el Barreal southeast to Mesa las Patadas], from which the coastal mountains immediately to the west cut off the cool damp coast winds." This mediterranean vegetation/Central Desert scrub transition was also described by Brandegee (1893).

After climbing a small pass 5 kilometers north of the headwaters of Cañada los Alamos, the Linck and Franciscan parties entered an arroyo at El Salto where they saw their first large forest of *Populus fremontii*. Linck described this arroyo as "covered on all sides with meadows and is thick with white poplars." Crespi wrote that this watercourse was originally named by Linck as "Arroyo de los Alamos...because of the large number of cottonwood trees on its banks."[6] Serra saw from a slope above El Salto "a pretty stream lined with cottonwoods and plenty of green." At present, the El Salto forest and another one downstream near the ranch of El Agua Escondida (30 kilometers west) are the southernmost stands of cottonwoods on our vegetation map. The El Salto stand is isolated and very likely the same population visited by the Spaniards. Serra also saw "all kinds of flowers" at this site, but it is uncertain whether he was referring to the blooms of annuals or woody perennials.

The usually terse Gaspar de Portolá, who apparently had little appreciation for plants, states that at El Salto he saw mesquite [*Prosopis glandulosa*] growing with the cottonwoods (Smith and Teggart 1909). Aerial photos show that *P. glandulosa* is common along most arroyos in this region, including El Salto and the nearby ranch of La Suerte (Plate 3). Wiggins (1944) recorded a population 10 kilometers farther north at San Pablo.

Leaving El Salto, the expeditions marched about 4 leagues (7 kilometers) to La Cieneguilla (a small swamp or wet place), in a basin at the foot of the southern Sierra San Pedro Mártir. This site is the junction from which the Linck expedition crossed the sierra to the desert. Little was mentioned of the vegetation there, although Crespi and Linck found pasture at the site, and Serra noted that the mountains were "all covered with flowers of various colors."

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[6] Because riparian forests usually indicate surface or near-surface water, the Spanish diaries provide detailed distributions of *Populus fremontii* and *Platanus racemosa* in northern Baja California. Accounts of these trees are consistent with modern distributions. *P. fremontii* was found on both the desert and coastal sides of the peninsular ranges, while *P. racemosa* was restricted to the coastal side (Minnich 1987a).

LINCK'S EXPLORATIONS OF THE SIERRA SAN PEDRO MARTIR AND THE SONORAN DESERT (1766)

In his search for the Colorado River, Linck's party climbed eastward from La Cieneguilla across the southern Sierra San Pedro Mártir, then skirted northward at the eastern base of the range about 35 kilometers to a point opposite Picacho del Diablo. In the mountains, Linck described riparian forests, chaparral, and palm oases. In the desert he provided brief statements on desertscrub, and on distant views of oak and pine forests on the high eastern escarpment of the sierra (Map 2A; Table 5).

The party suffered a difficult crossing of the mountains because, as Linck lamented, "the sierra seemed everywhere impenetrable"; however, after a day and a half of reconnaissances "they succeeded in finding a pass." Unfortunately, Linck gives insufficient directions to trace his route to the desert. Burrus (1966:fn.#54) concluded that the exploring party reached latitude 31°, "slightly north of San Felipe," before crossing the "spine" of the sierra. He based his interpretation on Linck's view of a "most extensive valley" as Valle de San Felipe. Linck's vantage to the east, however, does not provide diagnostic evidence of a specific route. The Gulf of California and the intervening plains can be seen from any part of the sierra. Moreover, the Sierra San Pedro Mártir reaches its greatest heights of 2,500 to 3,000 meters at latitude 31°, and the intense cold at such altitudes would preclude the presence of palms described during the crossing.

We believe that the Linck party took the easiest route through a pass whose location can be reconstructed retrospectively from his directions on the desert side. After their descent of the eastern escarpment on March 20, 1766, Linck marched four leagues north to another arroyo from which "water welled up from several springs—of varying degrees of heat—." These hot springs identify Agua Caliente (Appendix B; Burrus 1966, fn.#57B). The arroyo that the expedition descended (four leagues south) is mostly likely the drainage of El Berrendo, which is opposite the lowest point between Pico Matomí and the higher Sierra San Pedro Mártir to the north (30°32' N, 115°11'W; altitude: 1,390 meters). Thus, from La Cieneguilla, the Linck party most likely traversed eastward across the tributaries of Santa Eulalia and Los Corrales to a pass west of the canyon of El Berrendo. This descent would present fewer difficulties than other portions of the escarpment. The "extensive valley" seen to the east was probably Valle Chico (cf. Lazcano-Sahagún 1991). Although details are lacking in his diary, José Velasquez in 1775 may also have crossed the same area of the Sierra San Pedro Mártir from El Rosario before heading northward along the eastern edge of the sierra.

When Linck marched eastward to this pass from La Cieneguilla, crossing the arroyos of El Represo and El Rosarito, he wrote remarkable statements on the composition of vegetation. On March 17 he saw "from one of the heights...many pines {**pino**}, very tall palm trees {**palma**}, and white poplars {**alamos**}." Near the pass (March 18), he crossed arroyos "all dense with palm and poplar trees." The summary of his diary indicates he may have observed chaparral, which he describes as "evergreen oaks, which do not grow very tall." The mixing of palms with mediterranean scrub, and pinyons is an unusual species association because palm oases generally grow below the limits of mediterranean ecosystems; however,

Table 5. Summary of vegetation descriptions by Linck (1766) of the southern Sierra San Pedro Mártir and Sonoran Desert

Dates of Journeys[1]	Traverse Segment	Vegetation described
March 17-20	Crossing of the southern Sierra San Pedro Mártir	Chaparral, riparian forest, palm oases, pinyon forest
March 21-26	Desert along the east edge of the Sierra San Pedro Mártir	Desertscrub, microphyllous woodland, palm oases, riparian forest, Jeffrey pine forest on mountain summits

[1] For detailed route information, including place-names and latitude/longitude coordinate data, see Map 2A and Appendix B.

vegetation recorded in aerial photographs parallel Linck's observations. The southern Sierra San Pedro Mártir, west of El Berrendo, contains an abundance of *Brahea armata* growing along arroyos to as high as 1,500 meters, side by side with *Pinus quadrifolia* and chaparral dominated by *Adenostoma fasciculatum* and *Arctostaphylos peninsularis*. Linck did not identify the pines, but his comment that "few of them grow very tall" indicates that he saw pinyon forests (Burrus 1966:87), most likely *Pinus quadrifolia*.[7]

Once on the desert floor, Linck said more about the vegetation on the mountain slopes than in the desert. At Agua Caliente, palm oases were "seen on the mountain slopes and abundant pines on their summits." At present, palms are abundant in the upper headwaters of the southern tributaries of this drainage. From Linck's vantage, pinyon forests grow near the divide between Agua Caliente and the arroyos draining to the Pacific. It is noteworthy that Linck does not speak of palms farther north. Aerial photographs reveal that the palm oases at Agua Caliente are the northernmost populations on the eastern escarpment of the Sierra San Pedro Mártir (see Map 3).

At Cañada el Cajón, Linck saw many cottonwoods in the arroyo and numerous pines higher up on the sierra. A variant manuscript copy of Linck's diary (Burrus 1966: fn.# 62), states that "the sierra is crowned with many pine trees;" thus forests covered the upper slopes, but it is uncertain whether the term "crown" represents a specific observation (i.e., the trees occur on the crest of the range). The present-day view from the mouth of Cañon el Cajon reveals piñon forests beginning two-thirds up the escarpment (higher than 1,500 meters). *Pinus jeffreyi* forests silhouette the highest ridges.

[7] *Pinus quadrifolia* and *P. monophylla* were not distinguished by the Spanish diarists.

The final march of "five or six hours, always directly northward" brought the Linck party opposite Picacho del Diablo, possibly near Cañada la Providencia (Tiscareño and Robinson 1969; Plate 5). This locality is consistent with the local terrain and geology described by Linck. After leaving Cañada el Cajón, the expedition crossed four arroyos and camped at a fifth. Linck also noted that the mountain range began veering northwestward. In the vicinity of Picacho del Diablo, five arroyos come out of the range in succession, and the Sierra San Pedro Mártir doglegs northwest, then resumes its northward orientation. Linck also observed "whitish rock carried down by the rains onto the plains [which] makes it hard for the animals to tread." This white rock identifies a major east-west geologic contact on the escarpment at Cañada el Cajón that divides light-colored granites extending northward to Picacho del Diablo and beyond, from the slate/brown metamorphic outcroppings to the south (Gastil, Phillips, and Allison 1975).

Linck noted that mountains here contain "much timber: native pine, cottonwood, oaks {**encino**}, and other trees" that were washed down the arroyos. Likewise, Valasquez noted that the "high and white" summits contained considerable pine and oaks (Andrés-Zárate 1991). At present, the eastern escarpment at Picacho del Diablo is dominated by extensive pinyon forest, while the highest catchments are covered by mixed-conifer forest dominated by *Pinus lambertiana*, *Abies concolor*, and *Cupressus montana*. The oak is most likely *Quercus chrysolepis*, which is abundant above 2,200 meters.

Linck provided little information about the desert vegetation, despite having traveled through it for a week. In his diary summary (Burrus 1966:87), he mentioned that "the **medeza** trees [*Cercidium floridum*] become more abundant as one nears the Gulf of California," perhaps confirming present-day greater abundance of this microphyllous shrub east of the Sierra San Pedro Mártir than on the western slopes of the range. Linck also noted that "dense pasturage" (possibly desert wildflowers) covered the plain north of Cañada el Cajón. Velasquez recorded several shrubs in the eastern bajadas of the Sierra San Pedro Mártir including **uña de gato**, a shrub with fishhook thorns [*Acacia greggii* or possibly *Olneya tesota*], **palo medesa** [*Cercidium floridum*], **mesquite** [*Prosopis glandulosa*], and **Palo Adán** [*Fouquieria splendens*] (Andrés-Zárate 1991).[8]

FRANCISCAN JOURNEYS TO SAN DIEGO (1769)

At Cieneguilla, the Portolá expedition left Linck's trail to blaze a path of their own to the Pacific coast, and ultimately to San Diego. Crespi wrote in his diary at La Cieneguilla that the Franciscan friars "shall have to take another route, to the opposite coast" (from the route toward the Gulf taken by Linck, Bolton 1927:72). During this 300 kilometer journey, the two Franciscan parties, the first accompanied by Crespi and the other accompanied by Serra two month later, crossed the western margin of the Sierra San Pedro Mártir and the near-coast

[8] Because Valesquez is describing desertscrub, it is doubtful that he crossed the highest portion of the Sierra San Pedro Mártir, as suggested by Tiscareño and Robinson (1969). Rather than traversing pine forests through the range, he saw them at a distance from the desert.

ranges near Ensenada, as well as intervening valleys suitable for missions (Map 2 A,B; Table 6).

Sierra San Pedro Mártir foothills. The first leg of the Franciscan journey was a traverse through the western foothills (elevations greater than 1000 meters) of the Sierra San Pedro Mártir to Valle San Telmo, an area covered by *Juniperus californica* scrub, chamise chaparral, coastal sage scrub, oak woodlands, and even scattered pine forests. From La Cieneguilla, the party marched to the north-northwest "along the skirt of a high range" (the western escarpment of the Sierra San Pedro Mártir), first along a "beautiful plain," then through the dissected watersheds along arroyo San Antonio. The plain is an unnamed, northwest-trending linear bench that divides the sierra from coastal foothills and is crossed by small streams that drain into Cañon San Pablo.

Table 6. Summary of vegetation descriptions by Crespi and Serra (1769) from the Sierra San Pedro Mártir to San Diego

Dates of Journeys[1]	Traverse segment	Vegetation described
SAN PEDRO MARTIR April 1-10 (Crespi) May 27-June2 (Serra)	West foothills of the Sierra San Pedro Mártir	Desertscrub, palm oases, chaparral, riparian forest, oak woodland, pinyon forest, Jeffrey pine forest
April 11-14 (Crespi) June 3-5 (Serra)	Rancho San Antonio, Valladares	Maritime desertscrub, riparian forest
CENTRAL BASINS April 16-May 1 (Crespi) June 9-21 (Serra)	San Telmo, San Vicente, Santo Tomás, mountains east of Ensenada	Maritime desertscrub, chaparral, oak woodland, riparian forest, forbfields/ grassland
NORTH COAST May 1-13 (Crespi) June 21-30 (Serra)	Valle Guadalupe, coastal strip north to Tijuana	Maritime desert scrub, forbfields/grassland, oak woodland, riparian forest

[1] For detailed route information, including place-names and latitude/longitude coordinate data, see Map 2A,B,C and Appendix B.

Perhaps weary of the desolate country during the previous weeks, Crespi and Serra had much to say about the mesic vegetation they encountered along the bench. At "San Ricardo" (apparently the canyon of San Pablo), Crespi found that "although the land continues to be sterile as before, yet a difference is perceived, for now some live oaks {**encino**} are met with, although small, and some wild date palms." The small oaks probably represents Crespi's first observations of chaparral, which is abundant on the hillslopes just to the west. He may have recognized oaks, rather than other chaparral genera, because this genus is widespread in his native Spain. The "wild date palms {**palma**}" are probably *Brahea armata*, as seen on aerial photographs at Alamos Quemados and at San Pablo. This is the northernmost reference to palms on the Pacific slope of the Peninsular Ranges of northern Baja California by any of the Spanish diarists.[9] Just to the west of the bench was a "beautiful plain"...[with] much verdure, apparently a large meadow with willows along the arroyo of San José. Serra named this basin Santa Humiliana (El Agua Escondida). North of San Pablo, Crespi saw three streams crossing the plain, with one having groves of *Platanus racemosa*. This journal entry is close to the modern southern limit of this tree at San Pablo (30°41' N, 115°27' W). The place-name at the nearby arroyo of Alamos Quemados (literally "burnt cottonwoods") indicates that *Populus fremontii* was also present along these watercourses.

The expedition left the plain and descended into a basin called San Isidoro by Crespi, a place-name still in use. The diarists were impressed by groves of cottonwood along the stream in this basin, a southern tributary of the canyon of Santo Domingo. Serra described the vegetation with regard to a terrain feature that clearly pinpoints this site, stating there were

> Groves of cottonwood {**alameda**} and other trees more than in any mission, [and]...green [with]...the appearances of wheat fields with high green stalks...[and] what appears to be green bean fields. The leafy greenage of the place forms a semicircle with a rock-ribbed hill in the middle, on which the mission or village could be established.

San Isidro has a centrally located, steep, cone-shaped hill and is crossed by an arroyo draining westward from the Sierra San Pedro Mártir. A gallery forest of *Populus fremontii* follows a stream to the north of the hill, and a wet meadow surrounds part of the hill's perimeter (Plate 6).

The Franciscan expeditions proceeded northwestward across a series of ridges and canyons covered with chaparral, coastal sage scrub, and some of the most extensive cottonwood forests in northern Baja California. The parties descended west through a steep gully described as "rough and stony country" by Crespi—only to return to the southern branch of the canyon of Santo Domingo to a small basin he called San Vicente Ferrer. Both Crespi and Serra saw extensive forests of *Populus fremontii* along the stream. Crespi

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[9] The *Washingtonia filifera* groves at Valle las Palmas, the only other palm oases in coastal northern Baja California north of San Pablo, were not recorded at European contact. Orcutt (1883) described this population more than a century later.

recognized many other trees: "alders [**aliso** = *Platanus racemosa*], willows, some pines, live oaks, and wild grapes." The pines are probably *Pinus quadrifolia* which forms small populations on the slopes above the arroyo. The wild grapes are *Vitis girdiana*, a frequent stream plant. Live oaks {**encino**} may again refer to scrub oaks [*Quercus berberidifolia* or *Q. cedrosensis*], or shrubs with oaklike leaves such as *Prunus ilicifolia* or *Rhamnus crocea*. They may also be referring to *Quercus agrifolia*. In the Sierra San Pedro Mártir, botanical collections record *Q. agrifolia* as far south as Santo Domingo (30°48' N, 115°49' W).[10]

Crespi and Serra followed this canyon to another "large arroyo with plenty of running water" to a point immediately downstream from the present-day Rancho San Antonio. They describe the stream bed as "crowded with cottonwoods and willows." Crespi noted that the trees thinned at "a sandy stretch" near a waterfall and a nearby spacious plain, a pattern seen presently along this segment of the watercourse. Crespi made camp at a "large live oak," a definitive reference to *Quercus agrifolia*. Serra made the remarkable observation of "two big pine trees among the rest." These were probably *Pinus jeffreyi*, despite the fact the site's altitude is only 700 meters. This pine was seen there by Wiggins (1944:291), and in 1967 specimens were collected by Reid Moran (30°48' N, 115°39 W'), who noted on the botanical sheet that "this species was few and scattered near the river San Antonio" (Minnich 1987a). The 1906 Biological Survey reported that "willows, cottonwoods, and small oaks fringe the water courses here."

From San Antonio, the Franciscan expeditions trekked northwestward and crossed another series of ridges and canyons grown with chaparral and coastal sage scrub and returned to riparian forests at Valladares near the "foot of the sierra" (the western escarpment of the Sierra San Pedro Mártir).[11] Crespi described Valladares as "a leafy, verdure-grown arroyo...in which there is a large pasture." Serra found it "an ideal location for another mission and its farms—with timber without stint: cottonwoods, live oaks, and others." The reference to oak timber identifies *Quercus agrifolia*, which is common in the floodplain. This observation is particularly significant because neither Crespi nor Serra recorded *Q. agrifolia* between this site and Valle Santo Tomás, which is more than 100 km to the northwest, and it is consistent with the modern range of the tree (Minnich 1987a). Serra also saw the rose of Castile (almost certainly *Rosa californica*) from his camp along the arroyo of Valladares, in which there were "so many rose bushes that a purveyor of perfume could easily make a fortune."

Crespi provided a detailed account of the chaparral between San Antonio and Valladares: "All the ranges and hills that we crossed in this march are clothed in fragrant rosemary, with many small trees that resemble cypresses, junipers, small oaks, some pines, and other trees not known to us." The use of "clothing" to describe the vegetation on the slopes suggests

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[10] *Quercus agrifolia* was collected by Reid Moran near the coast in Cañon Santo Domingo near the mission of the same name. The observations of *Q. agrifolia* by the Spanish diarists from there northward are consistent with the modern range of the tree (Minnich 1987a).

[11] This is a grave site named for Crespi's translator, Manuel Valladares. It is now the ranch of the same name, located in the canyon of Valladares, 7 kilometers northwest of Rancho San Antonio.

that the cover was continuous. The fragrant rosemary is very likely *Adenostoma fasciculatum* or *Eriogonum fasciculatum*, whose foliage strongly resembles rosemary (*Rosemarinus officinalis*) of Mediterranean Europe. The small oaks {**encino**} are probably *Quercus berberidifolia* or *Q. cedrosensis*, or possibly other thick-leaved shrubs such as *Prunus ilicifolia* or *Rhamnus crocea*. Crespi had apparently not recognized other common shrubs in the genera *Arctostaphylos*, *Ceanothus*, *Rhus*, or *Malosma*. The reference to cypress {**ciprés**} is unclear, since Crespi distinguishes cypresses and junipers. The junipers are probably *Juniperus californica* seen already at El Salto. The Tecate cypress (*Cupressus guadalupensis* var. *forbseii*) does not occur at Valladares, although several populations are found on coastal foothills 20 to 30 kilometers west (Minnich 1987a). The cypresses may be generic names for taxa resembling a conifer, such as *Adenostoma sparsifolium*. The pines are very likely *Pinus quadrifolia*, which occurs in scattered groves between La Cieneguilla and Valladares.

Serra was also keenly aware of the change in vegetation: "It seems that the thorns and rocks of California have disappeared." He further stated that "it makes the third day [that] we have seen no **mescales**." They had not seen **mescal** (*Agave shawii*) between Valladares and San Pablo, and Serra added, "What the Indians eat here I don't know."

The Franciscan expeditions departed the Sierra San Pedro Mártir, moving west-northwest into an area of foothills southeast of the Valle San Telmo. Here, the Franciscans encountered a shift from chaparral to coastal sage scrub, with herbaceous cover in the basins. Crespi described a mesa and a large plain about 10 kilometers west-northwest of Valladares: "the land...continued sterile and with little pasture. The **cocoba** has followed us through all the marches up to the present, but here there was not even any firewood for our use" (*Simmondsia chinensis* was apparently a preferred fuelwood but was absent from this location). Serra distinguished the vegetation on hillslopes and valley floors. He saw a "large tableland [as] barren as could be...[which] has scarcely a bush, whereas the hills...are full of them. As to greenery—there are a few dried sticks—evidently the stalks of flowers that cover the tableland in the rainy season." These may possibly be tarweeds (*Hemizonia* spp.), which are abundant there. The spacious plain (possibly the modern Rancho el Carricito) was described by Crespi as "without pasture or water, or a sign of it." Even *Agave shawii* was absent. Serra noted that, "from the San Fernando district [San Isidoro] up to now, we had not seen...any **mescales**, nor any gentiles." In their daily observations of *A. shawii*, Serra and Crespi had thus far described its modern range. They saw this leaf-succulent daily between San Fernando Velicatá and Cieneguilla but realized in hindsight that the species was missing at higher elevations between La Cieneguilla and the small basins west of Valladares.

When the Franciscans pushed northwest from El Carricito, they entered dense stands of maritime desertscrub, which are seen presently along the lower foothills of the Sierra San Pedro Mártir. (Maritime desertscrub replaces coastal sage scrub below 500 meters altitude near El Carricito.) According to Crespi, "they encountered many **mescales**, the largest we have seen on the trip, and in such abundance that they was no room for the animals to step. Among them were many patches of **cocoba**." The east end of Valle San Telmo was also "crowded with **mescales**" (Plate 7). Serra described "fat, juicy **mescales**...[and] a few **jojoba**

bushes." He also saw Indians roasting mescal, stating that "on the fringes of the mesa are many fires,... [and] various little rancherías, and some roasted peelings which were clearly from **mescales**." Once Crespi arrived at the east end of Valle de San Telmo, he indicated that mescal is more abundant on the slopes than on the plains, as is the case today: "on departing this place [the east of the valley], we left behind the groves of mescal, which had been very annoying to the animals."[12]

The San Telmo plain was, according to Crespi "well covered with grass {**pasto**}, among which we saw some patches of tule [*Scirpus californicus* ?] from which water flowed." In the vicinity of a pond on the west side of this basin—which members of both parties used as a swimming hole—Serra saw a "green swamp of reeds...[and] a river with willows and vines." He declared the site to be suitable for a mission, stating that "the whole area...wants for nothing except that there is no timber to speak of but cottonwoods."[13]

Presently, maritime desertscrub and coastal sage scrub cover the hills surrounding Valle San Telmo. Chamise chaparral grows on scattered northern exposures just west of the village of San Telmo. Riparian forests are rare, even along the primary arroyo. The valley floor is mostly in cultivation, although some sections near the primary watercourse are covered by dense thickets of *Baccharis* spp. (Plate 8).

The grass {**pasto**} seen by Crespi and Serra at San Telmo probably consisted of forbfields. A century later, Orcutt (1886b:55) described fields of wildflowers at "San Telmo Canyon," about 20 kilometers west of the pond site. As he "wandered between the agaves and cactuses" there, he found

> Phacelia hirtuosa [*Phacelia*], and familiar plants seen in canyons near San Diego, collinsia bicolor [*Collinsia heterophylla*], Parry's phacelia [*P. parryi*], which is still common there, mimulus brevipes, krynitzkias [*Cryptantha*], chaenactis [*glabriuscula*?], galiums [*Galium* spp., and polycarpon depressum [*Polycarpon depressum*].

Wiggins (1944) saw wildflower fields a half century later in the San Telmo basin:

> nearly a solid blanket of color. *Layia platyglossa* formed large patches of pale cream-yellow, deeper yellow areas were formed by dense stands of *Baeria chrysostoma* var. *gracilis* [*Lasthenia californica*] and *Eschscholzia minutiflora* var. *darwinensis*, *Orthocarpus purpurascens* [*Castilleja exserta*] furnished pastel shades

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[12]The species composition of maritime desertscrub recorded by Mooney and Harrison (1972) above Valle San Telmo is consistent with Spanish accounts. They found an abundance of *Simmondsia chinensis* and *Agave shawii*, as well as by *Ambrosia chenopodifolia*, *Viguiera laciniata*, *Salvia munzii*, *Eriogonum fasciculatum*, *Lotus scoparius*, and *Rosa minutifolia* (see also Peinado et al. 1995b).

[13] The pond no longer exists. Because it was located near the arroyo of San Telmo, it was probably filled by sediment of a past flood. The most likely location, based on Crespi's directions, is the center of the basin that is about 5 kilometers east of the village of San Telmo.

of magenta and pale blue splashes around the bases of scattered shrubs were the blossoms of *Phacelia ramosissima*.

Above Rancho San José (Meling Ranch), Wiggins recorded other annual herbs including *Calochortus splendens*, *Delphinium parryi*, *Penstemon spectabilis*, *Mimulus brevipes*, and *Coreopsis californica*. Today, *Bromus rubens, Brassica geniculata,Erodium cicutarium* and other mediterranean exotics are ever more abundant, growing with *Hemizonia* spp. along basin floors and with maritime desertscrub on hillslopes, especially in the heavily grazed areas.

Central basins. For the next 100 kilometers to the north, the Franciscan journeys traveled through rolling country of foothills and plains, including the large basins of San Vicente, Santo Tomás, and present-day Ensenada. The missionaries described a mixture of coastal sage scrub and chaparral on the hills, and valley "grasslands." Riparian forests were recorded near springs and watercourses. A difficult ascent into the near-coast ranges between Santo Tomás and Ensenada brought the missionaries into an area of chaparral and coast live oak woodlands (Map 2A, B; Table 6).

The hills north of San Telmo were dominated by maritime desertscrub; Crespi and Serra saw **mescales**, **cocobas**, and **choyas** [*Opuntia prolifera*, *O. cholla*]. They camped along a stream that Crespi named San Rafael and was near the small present-day ranch of San Rafael de Abajo. Both diarists observed riparian forests of cottonwoods, sycamores, and willows downstream toward the Pacific coast. Presently, riparian forests extend continuously along this stream from the Sierra San Pedro Mártir to this site, and trees occur locally westward to the modern village of Colonet. Serra enjoyed this place because "it was encircled with mountains covered with green." It is uncertain whether he was referring to grassland, a doubtful prospect in May, or to rare coastal stands of evergreen chaparral. Orcutt (1886b:55) identified a chaparral stand near Colonet, where he saw "the last of Arctostaphylos bicolor [*Xylococcus bicolor*], adenostoma fasciculatum, and other northern shrubs."

The Franciscans followed maritime desertscrub between Rio San Rafael and El Salado, where Crespi wrote that the area, "continued sterile, and with cacti like [that during] the preceding [days]. The mountains...were very high and bare, with here and there a small tree." It is noteworthy that the reference to cacti at this locality is last mention of succulents of maritime desertscrub for 100 kilometers before they encountered them again north of Valle Guadalupe. Today, tall succulents of maritime desertscrub are scarce near El Salado, as this community becomes restricted to the coast from Erendira north to Punta Banda (Mulroy, Rundel, and Bowler 1979) and locally on coastal bluffs near Ensenada. A century later, Orcutt (1886b:55) marked the northern limit of maritime desertscrub near El Salado, stating that he saw "*Agave* [**mescal**, *Agave shawii*] in abundance one day's journey south of San Vicente."

Between El Salado and San Vicente, Crespi noted a change in the landscape: "Here the country begins to open, with meadows and hills stretching out, but the land continues with the same sterility and without firewood." This is the first reference during the journey to what appears to be extensive herbaceous vegetation, although the species composition was not indicated in the diaries. Exotic annuals had already invaded the bottomlands by the time

Orcutt (1886b:55) described this basin in the 1880s. At San Vicente, he saw houses "made of mustard stalks [probably the alien black mustard, *Brassica nigra*], tightly bound into a framework of poles, often forming only a circular corral...without a roof." This species was introduced by the Franciscans and had spread widely throughout California by the late eighteenth century (Heady 1988; Plate 9). Both Crespi and Serra admired a riparian forest of cottonwoods, sycamores, and willows at San Vicente.

The Franciscan missionaries traveled northwest from San Vicente toward Santo Tomás and described chaparral for the first time since they left Valladares in the Sierra San Pedro Mártir, which is its modern distribution. At Cañon Santa Cruz, Crespi "found the mountains and hills covered with some small trees similar to the juniper, and small oaks [scrub oaks]." The "juniper" there could not be *Juniperus californica*, which grows farther inland in the Sierra Juárez and the Sierra San Pedro Mártir, but may be *Cupressus guadalupensis* var. *forbseii*. This tree currently grows closer to the coast, near the groves of *Pinus muricata* seen by Orcutt (1886a:40) along Cañon San Isidro (Minnich 1987a). The juniper is more likely referring to common linear-leaf angiosperm shrubs, such as *Adenostoma fasciculatum*, or to species of *Baccharis* or *Ericameria*. Arroyo Santa Cruz itself was "full of sycamores and plenty of grass." Succulent vegetation continued to decline. Serra noted that **mescal** was absent at Cañon Santa Cruz. Near Agua Grande, Crespi described a valley with "plenty of grass," characteristic of several basins between San Vicente and Santo Tomás. He camped at one of the many riparian forests scattered throughout this area. Camp sites at Agua Grande and Cañon el Chocolate were placed along arroyos "full of sycamores and pasture."

The missionaries found the extensive basin of Valle Santo Tomás to be suitable for a mission. Crespi states that "there is enough pasture on the plain for the animals." During a walk to an arroyo that drains the valley to the west, Serra saw "hundreds of cottonwoods and hundreds of live oaks [*Quercus agrifolia*], ... some of extraordinary size." Aerial photographs show a substantial grove beginning just at the mouth of the valley and extending down canyon about 2 kilometers. *Quercus agrifolia* and *Populus fremontii* are the dominant tree species in this stand. The missionaries had not seen this oak since leaving the Sierra San Pedro Mártir (Plate 10). Serra also saw an abundance of chaparral at this site, stating that, "All the hills around are green and covered with trees." A soldier climbed a slope and told him that "there was an abundance of Rose of Castile bushes," probably *Rosa minutifolia* or *Adenostoma fasciculatum*. Both species were likely to be in full bloom when Serra passed through the basin in May.

Leaving Santo Tomás, the expeditions marched through a pass, most likely the route of the coastal highway to Cañon la Grulla (modern Uruápan). According to Crespi, "the whole ascent and descent...is full of live oaks," seemingly referring to both scrub oaks and *Quercus agrifolia*. Likewise, Serra "traveled up and down territory covered with live oak."[14] Dense chaparral now covers northern exposures there and *Q. agrifolia* is abundant along Cañon la

[14] Orcutt (1886b) wrote that the southernmost *Quercus agrifolia* along the coast was at La Grulla. His route through Santo Tomás was too far east to take him by known stands toward Bocana de Santo Tomás.

Grulla. The arroyo bed, according to Crespi, had "a good deal of marsh and wet land...that at first sight it looked like a cornfield" (Plate 11).

From La Grulla the Franciscans trekked northward into the near-coast ranges, rather than follow the more accessible Cañon la Grulla to the west toward Bahía Todos Santos (the bay of Ensenada). The vegetation in the near-coast ranges remained similar to that at La Grulla—chaparral, *Quercus agrifolia* woodlands, and riparian forests. At Cañon San Francisquito, Crespi saw "hills grown with groves of small oak and other trees not known to us." Serra noted that they "seesaw[ed] between mountains and valleys, all dry, but dotted with trees." Serra also wrote that this canyon and Cañon San Carlos "provided views of riparian forests of sycamores and big live oaks." The high mountains finally compelled the expeditions to descend Cañon San Carlos, which was described by Crespi as "a very deep dry run with live oaks and sycamores," to its mouth near the middle of Bahía Todos Santos (Ensenada).

The friars found the bay attractive. Crespi wrote that "it is a delightful place, all of level land, well covered with green grass, and [grass grew] near the hills, which are not very high." Again it is uncertain whether the pasture was dominated by grasses or forbs. Orcutt (1886b:54) described wildflower fields when he passed through the bay in 1886:

> We pass through Encenada (sic),...by magnificent fields of gold California poppy [*Eschscholzia californica*], *phacelias*, *layia elegans* [*Layia* sp.], *orthocarpus*, *baerias* [*Lasthenia* spp.], larkspurs [*Delphinium* spp.], *platystemon* and other delicate annuals and perennials which lent an added charm to the beauty of land and sea that was spread out before us on every hand. And thus for mile after mile we alternatively contemplate the rich garden of flowers and the beautiful scenery.

Today herbaceous cover at Ensenada is mostly dominated by exotic annuals, notably *Bromus rubens*, *B. diandrus*, *Avena barbata*, and *Brassica geniculata*, although wildflowers are seen occasionally in burns.

North coast. The last leg of the Franciscan journeys followed the coastal valleys and marine terraces from Ensenada to the international boundary and San Diego. The friars continued to report grasslands with coast live oak woodlands, but they also noted maritime desertscrub, which they previously saw south of San Vicente (Map 2B,C; Table 6).

The Franciscans proceeded northward along the perimeter of the bay through modern Ensenada and "around a range of hills that descend to this first [northern] curve of the bay," saying little of the vegetation. Orcutt (1886a:38) passed through this region and recorded a northern outpost of maritime desertscrub, noting "a little field of Parry's pretty rose [*Rosa minutifolia*], clusters of **pitahaya agria** [*Machaerocereus gummosus*], and various other species." He stated that these species reach their northern limit here.[15] The Franciscan

[15]A few succulents of maritime desertscrub, such as *Cereus emoryi* and *Opuntia prolifera*, occur as far north as San Clemente and Santa Catalina Islands in southern California (Haller 1988).



Plate 5. Aerial view of the eastern escarpment of the Sierra San Pedro Mártir. Picacho del Diablo (altitude: 3,100 m) is near the center. Microphyllous woodlands on the desert floor give place to pinyon forest at middle altitudes and to mixed-conifer forest on the summits. Photograph by Robert Thorne.



Plate 6. Aerial photograph of Serra's "rock-ribbed hill" at the center of San Isidoro Basin (*A*) on the west slope of the Sierra San Pedro Mártir. Streams and meadows aiign the north side *(right)* of this hill (north toward *right*).

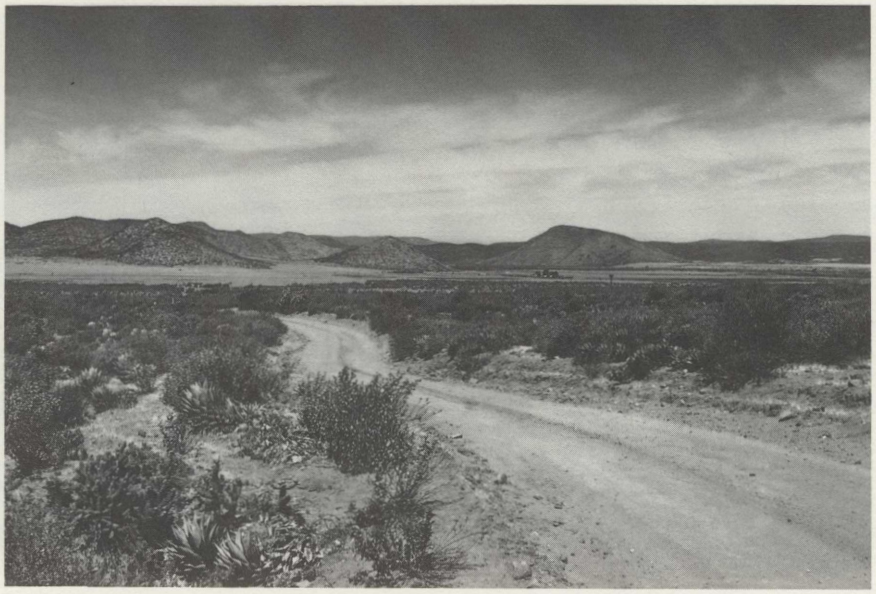


Plate 7. Maritime desertscrub on the east side of Valle San Telmo, dominated by *Ambrosia chenopodifolia*, *Agave shawii* (mescal), *Simmondsia chinensis*, *Viguiera laciniata*, and *Opuntia* spp.



Plate 8. View east across Valle San Telmo. The west face of the Sierra San Pedro Mártir is in the background. The "pool" of San Telmo, since filled by alluvium, was probably in the foreground.

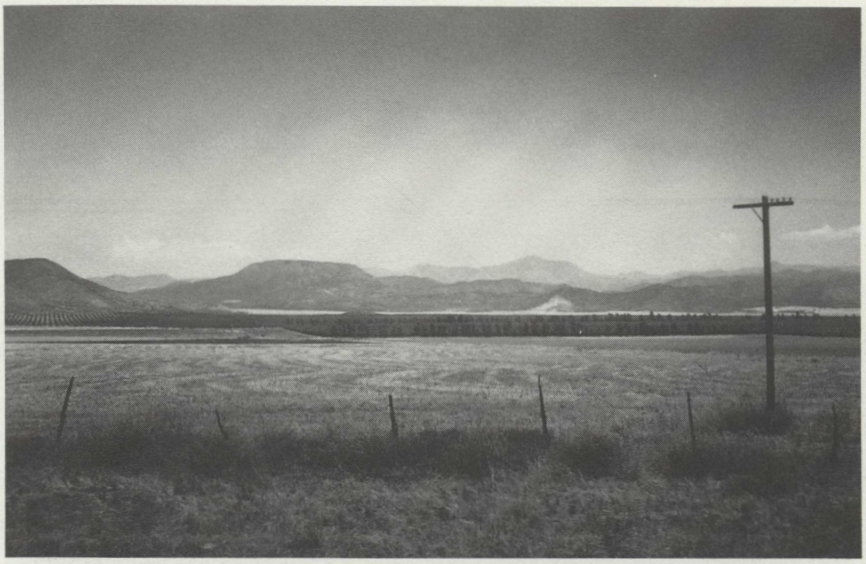


Plate 9. Valle San Vicente. Recently harvested wheat field with olive orchards and vineyards beyond. Crespi and Serra described meadows in this region. In 1886 Orcutt saw *Brassica nigra* used in the construction of huts.

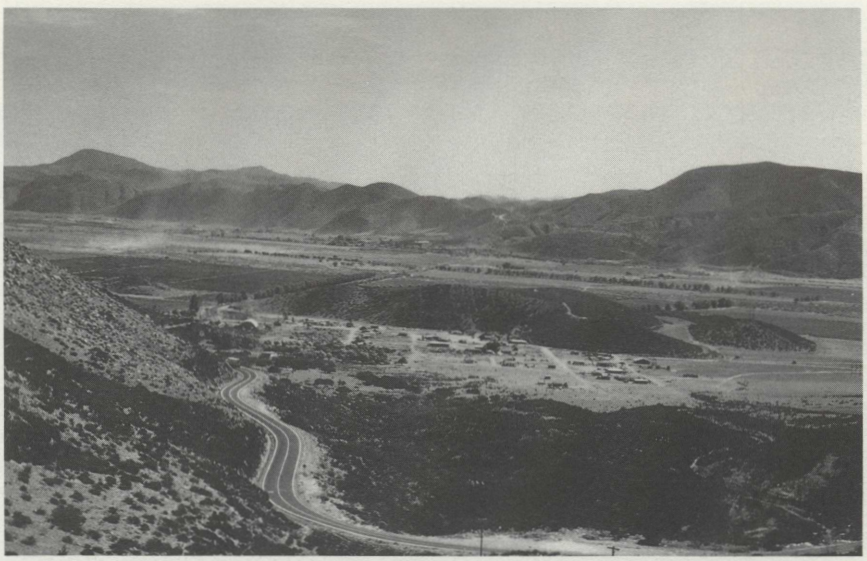


Plate 10. Valle Santo Tomás. Hillslopes surrounding the basin are covered by chamise chaparral. Spanish missionaries found some pasture in the valley, now mostly cultivated as vineyards.

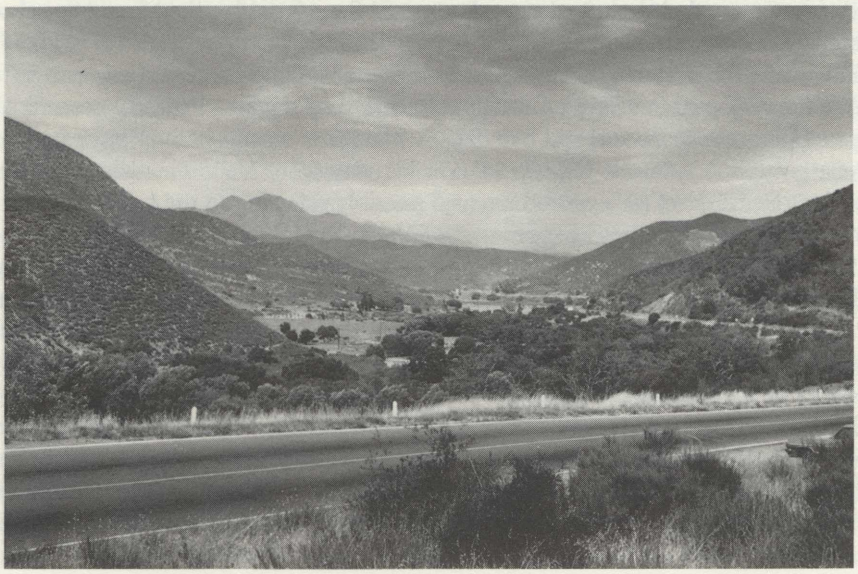


Plate 11. Arroyo la Grulla, visited by the Franciscan missionaries in 1769 and by Arrillaga in 1796. *Quercus agrifolia* woodland with cottonwoods near the stream. Chaparral in this area was described by Serra as "hills dotted with trees," and "chamizo" by Arrillaga 27 years later.

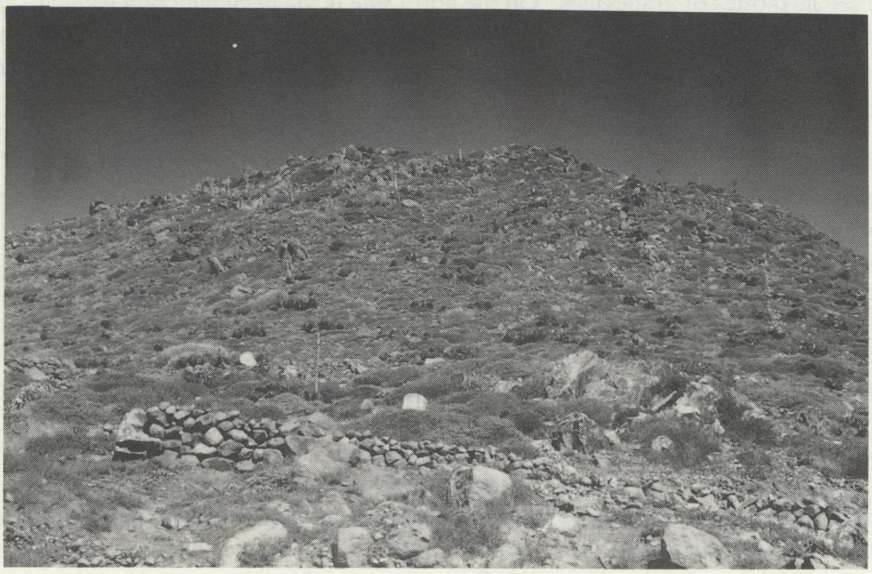


Plate 12. Outpost of *Agave shawii* near El Rosarito. Crespi stated that in this area "the **mescales** end, and that farther up [northward toward their destination at San Diego] no more are met with."

expeditions proceeded back to the seashore at El Sauzal, where they found "pools of fresh water and a very green meadow."

From El Sauzal, the Franciscan parties turned inland up "a very stony arroyo" (Cañon Arce) to the west margin of Valle Guadalupe, where they traversed "a very green arroyo, full of alders [*Platanus racemosa*] and live oaks." The friars may have overlooked a population of Tecate cypress. Orcutt (1886b:54), on his way from Valle Guadalupe to Ensenada, referred to one tributary as "cypress canyon," possibly referring to the grove now seen along Highway 3, about 5 kilometers southwest of Valle Guadalupe.

Serra and Crespi described Guadalupe as "an immense valley with wonderful pasture, [and] plenty of trees at its extremities...We slept under the stout branches of a monster live oak" [*Quercus agrifolia*]. Crespi wrote that this basin had "a great deal of pasture [and] trees at its ends." Today, most of the valley is cultivated, but *Q. agrifolia* woodlands with an understory of exotic annual grassland occur along the perimeter of the basin. When William M. Gabb passed through Valle Guadalupe during his journey through the entire peninsula in 1866-67, he wrote that "the grass in the uncultivated parts of the valley was unsurpassed by anything we saw on the whole journey" (Orcutt 1886a:38). We wonder whether he described exotic annual grassland because the wild oat (*Avena fatua*) and black mustard (*Brassica nigra*), a deliberate Franciscan introduction, had already naturalized throughout coastal Alta California by the mid-nineteenth century (Parry 1859), and the bottomland at Valle Guadalupe is ideal habitat for them.

The Franciscans soon encountered two more attractive valleys: San Marcos and Boquilla de Santa Rosa. Crespi described San Marcos as a place that "looked like a mission already established...on account of the verdure, which resembled a cornfield." At Boquilla de Santa Rosa, Serra found the ground "covered with rushes {**caña**} and tule, and among the willows you see quantities of grapevines. On the north side is the beginning of a canyon...chokefull of massive trees with enormous branches" [*Quercus agrifolia*]. Presently both basins are covered by exotic annual grassland, surrounded by hillslopes with coastal sage scrub, chaparral, and scattered coast live oak woodlands.

Where Crespi's party pitched camp on a mesa near San Marcos, he described the area as "having an abundance of grass and **mescales**." This is his first observation of **mescal** (*Agave shawii*) since leaving San Vicente. (He seems to confirm the present-day scarcity of mescal between San Vicente and this site.) A nearby mesa had "an abundance of wild beans...which seemed...very little different from the cultivated or ordinary beans." It is doubtful that Crespi was referring to the domestic bean [*Phaseolus atropurpureus*], because pre-Spanish agriculture is not known in northern Baja California (Bean and Lawton 1973). Perhaps he was describing *Lotus scoparius* or some other legume. After crossing the mesa west of the canyon of Guadalupe, both Crespi and Serra described a very steep descent to the mouth of this stream to present-day La Misión. Both friars stated that the riverbed was covered with reeds, rushes, and groves of large trees.

The remainder of the Franciscan expeditions traced the immediate coast to the modern international border. Crespi noted the coastal sand dunes north of La Misión. Both Serra and Crespi observed that the coastal vegetation had a succulence they had not seen since El Salado, 100 kilometers to the south. Serra observed that "the ground was largely covered

with juicy **mescales** [*Agave shawii*]—a tree we had not seen for a long time. Besides, here and in the three previous stopping places [between Valle Guadalupe and El Rosarito] there are lots of **nopales** and **tunas** [platyopuntias], fruit seldom seen before." The **nopal** is probably *Opuntia littoralis*, which has its southern limit near El Rosarito (Wiggins 1980). Crespi called them "prickly pears with sour fruit." He also specified that at some point between Cañon el Descanso and El Rosarito, "the **mescales** end, and that farther up no more are met with" (Plate 12). Today, most marine terraces between La Misión and Tijuana are cultivated or urbanized; however, the distribution of surviving mescal is similar to that in these accounts. *Agave shawii* forms dense cover with coastal sage scrub along the coastal strip northward to El Rosarito. Outposts are found at the international boundary on steep slopes and cliffs, possibly off the Franciscan route.

The vegetation became more herbaceous as the Franciscans approached the international boundary. Near El Rosarito, Serra wrote that the "surrounding hillsides [were] covered with good grass {**pasto**}". During his final march in Baja California, Crespi came upon a view of Tijuana and the coastal plains of San Diego, describing the latter area as a "long stretch of level shore...being well covered with green grass." In 1886, the Tijuana area was described by Orcutt (1886b:53) as an area with "extensive fields of alternate patches of blue, white, pink or yellow wildflowers." Today's vegetation north of El Rosarito is mostly exotic annual grassland, with coastal sage scrub on the hillslopes.

4

EXPLORATIONS OF THE INLAND MOUNTAINS AND SONORAN DESERT

Twenty years after European contact with northern Baja California, after the Dominican mission system was established along the coast, two major expeditions were undertaken to explore the inland mountains and deserts. In 1792, José Longinos-Martínez led a small party into the Sierra San Pedro Mártir. Four years later, José Joaquin Arrillaga spent the summer and fall making extensive explorations of the mountains surrounding the prospective mission site of Santa Catarina.

LONGINOS-MARTINEZ'S TRAVERSE OF THE SIERRA SAN PEDRO MARTIR (1792)

When he visited mission Santo Domingo, the Indians told José Longinos-Martínez of a lagoon on the summit of the Sierra San Rafael (Sierra San Pedro Mártir), which they described as "a beautiful, level place [a plateau] in spite of the rough appearance of the mountains" (see the summary of Longinos-Martínez's dairy in Simpson 1938, 1961). The Indians asserted that the "lagoon...contained fish and sea otters [and that] he who got wet in that water, or looked at it, or drank of it, died at once." Longinos-Martínez decided to find the lagoon and explore the mountain. He also made an unsuccessful attempt to cross the desert to present-day San Felipe, which is on the Gulf of California, to ascertain this site's value as a port. The brief account of his journey provides the only substantial description of the conifer forests of the Sierra San Pedro Mártir from the late eighteenth century (Map 2A,B; Table 7).

Longinos-Martínez first trekked inland from the mission to Valladares "over a bad road of hills and canyons" (most probably Cañon Santo Domingo). He gave a representative list of dominant species of maritime desertscrub, coastal sage scrub, chaparral, and riparian forests now seen in this area: "The way was thick with roses of Castile, rosemary, poppies (*Papaver californico*) [*Eschscholzia californica* or *E. minutiflora*], juniper, alder or *Betula*, willow, sage (both the apothecary's and *Salvia californica*), etc." This is the only statement by any diarist that uses both "rose of Castile" and "rosemary" together, thus establishing a taxonomic distinction between them. As described by Serra, the rose of Castile is probably a true rose. Longinos-Martínez was most likely describing *Rosa minutifolia*, which is a dominant member of maritime desertscrub along the coast and inland past Mission Santo Domingo to near Valladares. He may also have been referring to *R. californica,* which grows

Table 7. Summary of vegetation descriptions by Longinos-Martínez (1792) of the Sierra San Pedro Mártir

Dates of Journeys[1]	Traverse segment	Vegetation described
July 17	Arroyo Santo Domingo to the west flank of the Sierra San Pedro Mártir	Maritime desertscrub, coastal sage scrub, riparian forest
July 18	Sierra San Pedro Mártir plateau	Jeffrey pine forest, mountain meadow, montane chaparral
July 19	Sonoran Desert	-
July 20-21	Ascent of eastern escarpment to Vallecitos	Mixed conifer forest, mountain meadow
July 22-23	Return to Santo Domingo	Maritime desert scrub

[1] For detailed route information, including place-names and latitude/longitude coordinate data, see Map 2A,B and Appendix B.

along streams but possesses an inflorescence likely to attract the attention of a European-trained botanist. Longinos-Martínez traveled in July when both species are likely to be in flower. He may have equated the European "rosemary" [*Rosemarinus officinalis*] with one or several of the linear or fasciculate-leaved shrubs, most likely *Adenostoma fasciculatum* or *Eriogonum fasciculatum*, which are common on the hillslopes of the canyon of Santo Domingo. Two "sage" species were also recorded. The apothecary's sage was identified by Longinos Martínez as *Salvia officinal* (Simpson 1961:81). Thus, it is probably a true sage, inasmuch as this genus occurs in Mediterranean Europe and would be familiar to him. He may have been referring to *Salvia apiana,* which is widespread on the foothills of the Sierra San Pedro Mártir, including the slopes at Valladares. The "*Salvia californica*" observed by Longinos-Martínez is apparently another aromatic shrub, possibly another true *Salvia* or possibly *Artemisia californica*.

In addition to coastal sage scrub and chaparral taxa, Longinos-Martínez listed juniper [*Juniperus californica*] that was also seen at the base of the Sierra San Pedro Mártir by Crespi and Serra. His list also includes the common riparian trees along the canyon of Santo Domingo: alder [*Platanus racemosa*], *Betula* [literally birch, *Populus fremontii*], and willow [*Salix* spp.]. Longinos-Martínez, as did Crespi and Serra 23 years before, described Valladares to be very green.

After leaving Valladares, Longinos-Martínez made a very difficult ascent of the western escarpment of the Sierra San Pedro Mártir. This escarpment is uniformly precipitous and

would permit an ascent in only a few localities. We believe he followed the modern route of the seasonal cattle drives between Valladares and the mountain meadows (Plate 13). Longinos-Martínez first followed a stream along arroyo Santa Cruz "to its source"—a place where water bursts out of the mountain, probably El Descanso on the western escarpment. This is a definite locality because the stream begins at an impressive spring that discharges halfway up the escarpment. His party then followed the present well-developed trail up "a very steep slope," to camp on a "rest or small plain." An ascent from El Descanso would most likely lead them to a 10-hectare basin just east of the lip of the escarpment (altitude: 1,670 meters).

The pine forests that were encountered the following morning appear to have the same distribution as that today (Plate 13). Longinos-Martínez continued upslope, reaching the summit dividing the Valladares drainage from the Sierra San Pedro Mártir plateau and three meadows he would see later in his journey. Assuming he followed the modern cattle trail, the summit is just north of La Zanja at an elevation of 2,200 meters. Longinos-Martínez suggested that broken forests began halfway up to the summit from his camp, then became continuous at the summit: "scattered pines {**pino**} begin to appear at the middle of this ascent, and the summit is covered by a thick forest of several species of immense pines." Today, the first pines appear along the Santa Cruz watershed at about 1,800 meters, 3 kilometers east of the "rest." Longinos-Martínez's route then crossed another pine-forested basin at 1,950 meters. Unbroken forests began at 2,000 meters, about 3 kilometers west of the pass. Longinos-Martínez was no doubt referring to *Pinus jeffreyi*, which is the overwhelming dominant of mixed-conifer forest there, although *P. lambertiana* occurs locally on rocky hillslopes.

Longinos-Martínez's party then passed through the three primary meadows of the sierra: La Grulla, La Encantada, and Santa Rosa. The first meadow, La Grulla, was reached after traveling two hours "through a forest east northeast, crossing some hills and ravines." He presented a remarkably accurate depiction of the modern landscape of this basin:

> It is a level place of perhaps half a league in length and half a quarter [sic] in breadth, thickly covered with **cynodon** or possibly couch grass (*Triticum Repens*), and with no trees and shrubs, surrounded by the pine woods and by very high ranges of mountains and outcroppings of live rock. This flat is crossed by a narrow little creek half or three-quarters of a vara in breadth, and two varas in depth....This creek has its source in the lavas of the highest mountains to the north of the valley [the slopes separating La Grulla from Vallecitos].

Aside from being the first meadow to be encountered in his journey, the identification of La Grulla is made more certain by Longinos-Martínez's depiction of granite bedrock slopes (lavas) to the north (Plate 14). Herbaceous species identified by Longinos-Martínez are uncertain, as the **cynodon** is not Bermuda grass. Presently, La Grulla is dominated by *Juncus*, *Carex*, and herbaceous dicot perennials and annuals. The couch grass may be *Muhlenbergia minutissima*. *Triticum* is an herb resembling wheat, possibly *Agrostis exarata* or *Piptochaetium fimbriatum*.

Nelson's account (1921:21) of La Grulla resembles that of Longinos-Martínez: "The main meadow at La Grulla is a narrow, winding, grassy valley several miles long, amid a beautiful pine forest....To the north and east, high ridges of granite covered with bowlders [sic] of the same formation rise almost barren of vegetation above the belt of pine trees which forms a girdle about each of the parks, thus giving the ridges the appearance of projecting above timber line."

Longinos-Martínez then "continued in the same direction [eastward from La Grulla], over plateaus and through ravines" for another hour, reaching the second meadow which he described as

> a beautiful valley, also free from trees and covered with **cynodon**, about two leagues in length and half a league in breadth. The pines around it are astonishing. I measured several of them which were fourteen to sixteen varas in circumference. The forests surrounding this valley continue to the foot of some ranges of steep, high, and rocky peaks....The valley is watered by five large streams which come in from different directions, and at its entrance, where all these streams discharge, it is somewhat marshy, and there is a deep pond there.

This site is certainly the meadow of La Encantada, which is approximately 5 kilometers east of La Grulla. The relative dimensions given (two leagues by one-half league) accurately describe the size of this rectangularly shaped basin. The steep, high, rocky peaks are apparently the summits of Tres Palomas on the eastern divide. Many streams flow into the meadow, and there is a small pool where the trunk stream exits the basin for La Grulla. Pine forests were abundant along the margins of the meadow "to the foot of some ranges," as seen today (Plate 15). Longinos-Martínez described several shrub and herb species on the hillslopes, including "a great deal of sage, **madroño**, tobacco [*Nicotiana attenuata*?], rose of Castile, larkspur, etc." The "sage" is most likely *Salvia pachyphylla* (rose sage), a pungent subshrub that grows extensively in flats and along the margins of meadows and blooms in summer. The "rose of Castile" is obscure because no member of the genus *Rosa* grows in the high mountains, nor does *Adenostoma fasciculatum*, another member of the rose family. (Perhaps he was referring to the "rose sage.") The **madroño** is not madrone (*Arbutus* spp.) but refers to widespread stands of *Arctostaphylos peninsularis*, *A. pringlei*, and *A. pungens* on the hillslopes surrounding this and other nearby basins.[1]

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[1]The term **madroño** had apparently become common usage by the 1790s, because it was frequently used by Arrillaga. Perhaps the Spanish use of **madroño** is the basis for listing of *Arbutus menziesii* as a common species in the Sierra Juárez and Sierra San Pedro Mártir (Wiggins 1980; Tiscareño and Robinson 1969). However, *Arbutus menziesii* has not been collected in Baja California (the southern limit of this tree is on Mount Palomar in San Diego County [Griffin and Critchfield 1976]. We believe the Spanish diaries are referring to *Arctostaphylos* spp. which have similar foliage and inflorescences, and the smooth reddish-brown bark of the Strawberry Tree (*Arbutus unedo*, strawberry madrone), which is found throughout the Mediterranean, including Old Spain (Minnich 1987a). *Arctostaphylos* also resembles *Arbutus andrachne* of Greece and Turkey. **Madroño** also appears to be a generic term analogous to chamisal, or a stand of brush dominated by chamiso. Thus, we ascribe the term **madroño** to chaparral dominated by *Arctostaphylos*.

In the meadow, Longinos-Martínez found cynodon and flax, possibly referring to *Linum lewisii* (a native flax), a slender erect annual, or possibly *Muhlenbergia*. He described La Encantada "in the center of the summit of the Sierra" and later in the diary called it "Las Animas" [literally, "the ghosts or spirits"].

Continuing his journey, Longinos-Martínez's diary records what we believe is an error in his route description. He claimed to "continue in the same direction" (east-northeast) to the "great water." However, this bearing from La Encantada would bring him to the precipitous eastern escarpment, and furthermore, the three great meadows do not form a line on the compass. We believe that Longinos-Martínez went southeastward to a lake that drowned the meadow of Santa Rosa. The estimated three hours of travel, according to his diary, is a reasonable distance between La Encantada and this meadow. Santa Rosa is also a topographic depression that fills with water after abnormally heavy rains (Plate 16). Longinos-Martínez probably visited the sierra after an unusually wet winter.

The meadow of Santa Rosa, named "El Carmen" by Longinos-Martínez, was clearly his favorite of the sierra (Plate 17):

> The two valleys which we had seen have excellent advantages, but they were not to be compared with...this place, to which we gave the name of El Carmen. This is an enclosed valley which gives a beautiful view...from any point. It is free from all trees and shrubs, surrounded by level forests of very large pines. [The basin has] several outlets to other, smaller valleys, and is watered by three large streams, which are sufficient to water the whole floor of the valley. This valley is so covered with flax that it seems to have been sown with it.

His descriptions of topographic features identify the valley as Santa Rosa. In addition, three small streams enter the valley, two from the east near the escarpment, and one from the north. Two smaller valleys connect with the northwestern and southeastern sides of Santa Rosa. Longinos-Martínez also described a wide ravine to the northeast of the meadow to the edge of the eastern escarpment that uniquely differentiates Santa Rosa from the other two meadows.

The vegetation is similar to that at La Grulla and La Encantada. Pine forests were most abundant around the perimeter of the meadow. The meadow seemed to have more tall grasses [flax] than the others. Chaparral on the surrounding hillslopes did not capture Longinos-Martínez's attention. His observations of the lake indicate that its size was unusual: "the animals...seen [by the Indians] from a distance were only trees in the lake." Jeffrey pine, the only conifer in the basin, would perish in standing water within a period of months.[2]

The Biological Survey of 1906 provides a similar description of this meadow, except that this expedition arrived during a dry year. According to Nelson (1921), Santa Rosa is "another beautiful park at about the same altitude [2,200 meters] as La Grulla. It is a

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[2] Simpson (1961) concluded that Longinos-Martínez visited the "great water" at La Encantada to which he attributed the name El Carmen (see map of "Mission Rosario to San Francisco"). However, the La Encantada basin contains no topographic depression that could hold a lake the size indicated by Longinos-Martínez.

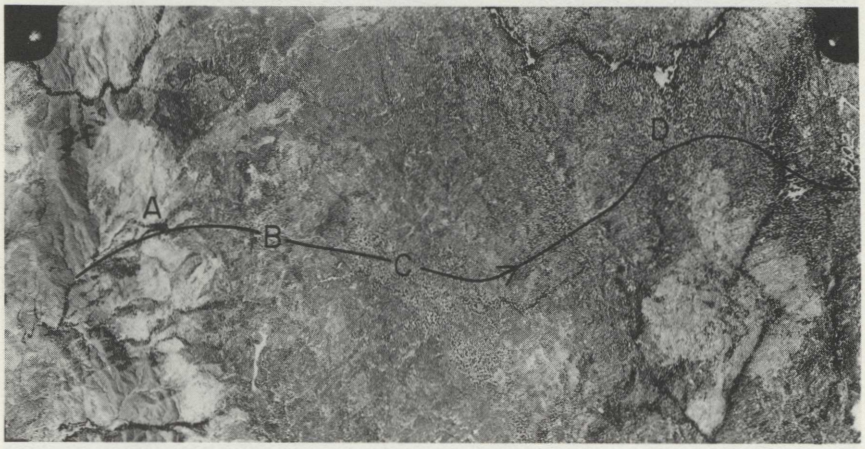


Plate 13. Aerial photograph of the chaparral-covered west slope of the Sierra San Pedro Mártir between Valladares and La Grulla showing Longinos-Martínez's probable ascent of the range in 1792 (scale: 1:50,000). His route may have followed the modern cattle-drive trail vaguely seen in the chaparral (north to *top*). From El Descanso, a large water source of the canyon of Santo Domingo, (*A*), he ascended a steep slope to a small plain at the western lip of the plateau (*B*). Continuing eastward (follow trail toward the *right*), Longinos-Martínez climbed into "scattered pines" (dark dots: *Pinus jeffreyi*) seen halfway up this slope, apparently the pine forests in two basins of Arroyo Santa Cruz (*C*). He reached continuous forests just below a pass (*D*).

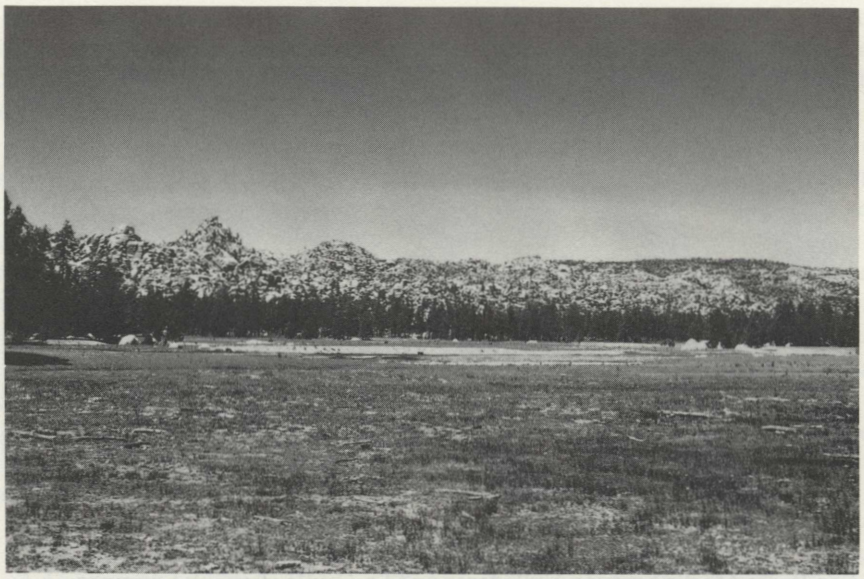


Plate 14. La Grulla Meadow (altitude: 2,100 meters) and Jeffrey pine forest. Rocky granite slopes beyond were described by Longinos-Martínez in 1792 and by E.A. Nelson of the Biological Survey in 1906.

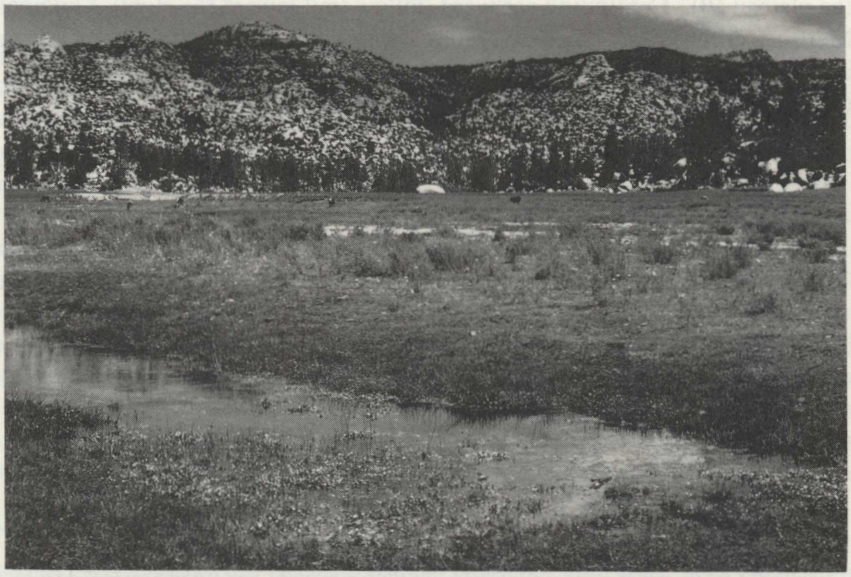


Plate 15. La Encantada meadow bordered by Jeffrey pine. Longinos-Martínez and Arrillaga state that the rocky slopes behind are covered with rose sage [*Salvia pachyphylla*], **madroño** [*Arctostaphylos* spp.], and oaks [*Quercus chrysolepis*]. Cattle graze on the far side of the meadow.

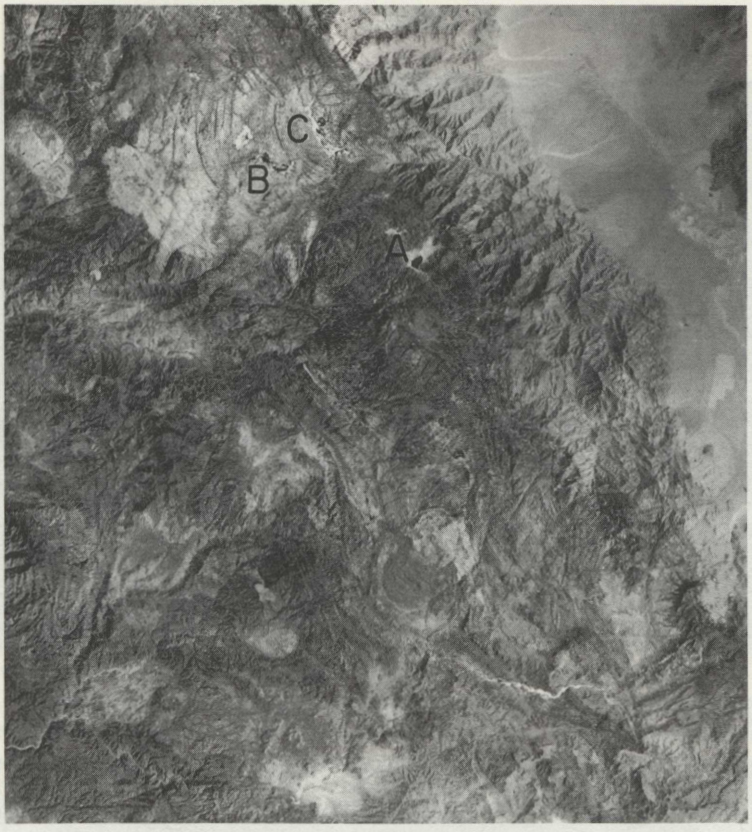


Plate 16. Landsat image (May 30, 1980) of the Sierra San Pedro Mártir and the lake at Santa Rosa (*A*), filled by flooding rains the previous winter. La Grulla (*B*) and La Encantada (*C*) meadows are seen to the north.

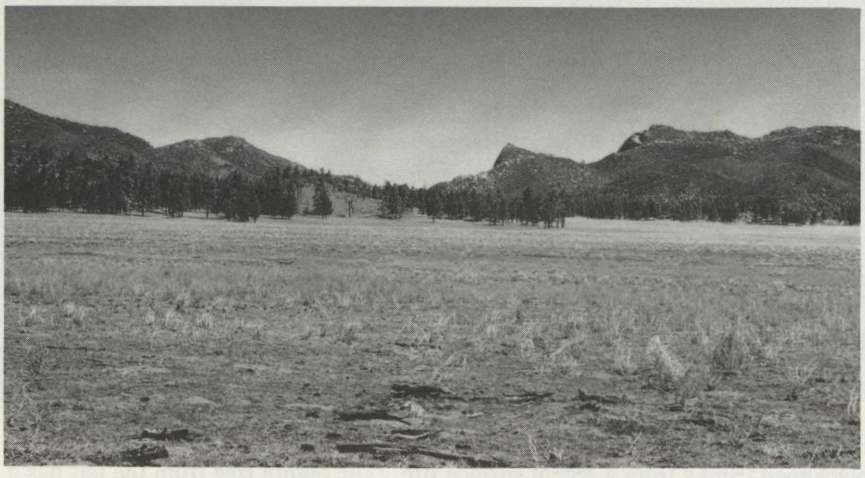


Plate 17. Santa Rosa meadow, surrounded by Jeffrey pines, with chaparral on the hillslopes. Longinos-Martínez visited a "lagoon" at this site to break a superstition among the Indians of Mission Santo Domingo that the lake would cause them harm. The low pass in the skyline was crossed by Longinos-Martínez to the eastern escarpment, which he descended to the San Felipe desert along Cañada el Cajón. Several burns cross the chaparral on the distant slope (*middle right*).



Plate 18. Mixed conifer forest of *Abies concolor* (*left*), *Pinus lambertiana*, and *P. jeffreyi* on a north-facing slope of the high Sierra San Pedro Mártir.



Plate 19. Open jeffrey pine forest at Vallecitos in 1903. Trees display blackened trunks from a recent surface fire. The eighth tree from the left has a basal cavity or "catface." Photograph by Ford Carpenter. (Reproduced by permission of the Mandeville Special Collections Library, University of California, San Diego)

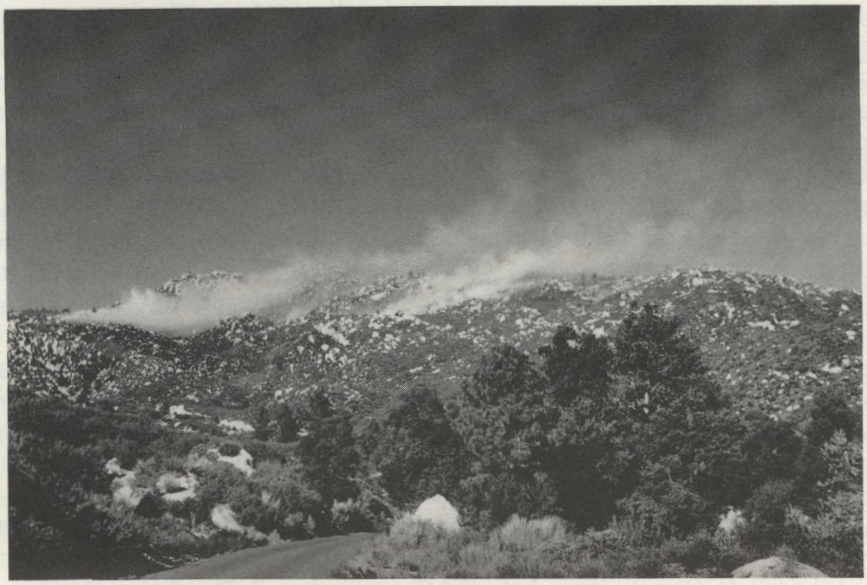


Plate 20. La Concepción, a small basin with *Quercus agrifolia* woodland. Longinos-Martínez's party was attacked by Indians here. The lightning-set fire in the background crept across 200 hectares of chaparral and Jeffrey pine forest over a period of 17 days in September 1987.

waterless grassy valley like a shallow basin in form, about 2 by 3 miles in extent, and is bordered by low, pine-covered hills." In December 1887, this basin was described by Ed Griffin as "being centered on the eastern side of the range" and having "four clean-cut avenues open[ing] into it from four points on a compass. He stated that the meadow was "500 acres of grass land (sic)...[and] so regularly arranged in trees...that a landscape gardener would find nothing to alter or improve." Just to the east, Griffin saw the eastern escarpment, the desert, and the Gulf of California (*Lower Californian*, May 9, 1890).

Longinos-Martínez took the wide ravine to the northeast end of Santa Rosa and descended the eastern escarpment to the "Valle de San Rafael [Valle Chico], and the port of San Felipe de Jesús." This ravine led him down the southern branch of Cañada el Cajon, where he may have intersected Linck's route of 1766. Unfortunately, he left no account of the vegetation on the eastern escarpment, nor of the desert, except to mention that it "abounds in mescal" [*Agave deserti*], and that the Indians of the Colorado River (Cucupi) grew crops of maize, squash, and watermelons.

Wiggins (1944) described the modern vegetation pattern of Cañada el Cajon in 1941: "as one goes eastward through the pass and down the trail leading to El Cajon [the trail can still be seen on the aerial photographs], he passes abruptly out of *Pinus jeffreyi* forest into a scrubby scattered cover of *Ceanothus greggii* var. *perplexans*, *Ceanothus leucodermis*, *Arctostaphylos patula*, *Quercus chrysolepis*, and *Q. peninsularis*." The chaparral association "on the eastern side...is confined to a comparatively narrow altitudinal band" before it gave way to desert scrub.

Longinos-Martínez was unable to venture far toward San Felipe because of threats from the Indians. He "returned the same way" (i.e., via Cañada el Cajon back into the Sierra San Pedro Mártir), but took a different route from "south to north" across the Sierra that includes "a very bad ascent to the summit... in the vicinity of Las Animas" (La Encantada).[3] Since Longinos-Martínez was near the "central valley" of the sierra, the party may have climbed the northern branch of Cañada el Cajon to the vicinity of Cerro Botella Azul or some other location along the escarpment east of La Encantada. After reaching the highest part of the mountain, the party descended "a very steep slope to a flat," almost certainly Vallecitos. Here he makes a remarkable observation that "the range is thickly covered with pines (different species from those in the lower mountains)," in apparent recognition of the richer mixed-conifer forests of *Pinus jeffreyi, Abies concolor*, *Pinus lambertiana*, *Calocedrus decurrens*, and *P. contorta* that cover the highest plateaus of the range (Plate 18).

Almost 100 years later, the San Pedro Mártir forests were examined in detail in an extraordinary 76-day survey in 1888 by Colonel D.K. Allen, land inspector for the International Colonization Company, a London-based firm that attempted to settle parts of Baja California, particularly along the San Quintín coastal plain (*Lower Californian*, March 29, 1888; April 19, 1888; December 26, 1890). Because his company was interested in

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[3] It appears Longinos-Martínez was spooked by the mountains, thus inspiring the place name "La Encantada" ("bewitched"). La Encantada's location more accurately fits Longinos-Martínez' description, "central valley of the range," than does Santa Rosa.

logging the forests of the Sierra San Pedro Mártir, Allen's analysis includes not only species lists but also stand densities and stem-diameter characteristics. His sample of "54 acres [22 hectares] of conifer forest, selected in different parts of the pine [forest]," includes sites in the mixed-conifer forests of Vallecitos. The forests were also very open. Allen found that a one-acre (0.4-hectare) stand contained an average of 25 "large trees" (62 per hectare) and seven "small trees" (25 per hectare). Among the large trees, there was an average of 17 "Norway pines" [*Pinus jeffreyi*, 42 per hectare], four "white pines" [*P. lambertiana*, 10 per hectare], three "fir trees" [*Abies concolor*, 7 per hectare], and one "red cedar" [*Calocedrus decurrens*, 3 per hectare]. Allen saw trees as tall as 60 meters with diameters as great as 2.4 meters. In a sample of three acres, most large trees had diameters between 0.8 and 1.6 meters (Table 8).

The Biological Survey affirms the open structure of forests at Vallecitos in 1906. According to Nelson (1921:20), the survey "crossed several rounded ridges covered with an open growth of yellow pines." They also saw "patches of aspen [*Populus tremuloides*] ...among the pines on north [facing] slopes, and grass and other herbage on open flats." The Vallecitos meadows were described as "a series of beautiful flat-bottomed grassy parks... overgrown by an open forest of yellow pines [*Pinus jeffreyi*] mixed with a few other conifers." (They published several photographs of parklike forests.) Photographs taken by Ford Carpenter during an expedition in 1903 also show open forests throughout the northern half of the range (Plate 19). The species composition of the Sierra San Pedro Mártir forests was accurately in 1907 by A.W. North (1907), an avid hunter and camper in northern Baja California.

Longinos-Martínez was unimpressed with the pasture at Vallecitos, stating that the area is "without plants [little or herbaceous cover], there being hardly any cynodon, even at the summit." It appears that herbaceous cover was scarce in this basin, then as now, even before cattle grazing was introduced to the region. Perhaps he did not cross the meadows.

Longinos-Martínez made few remarks about the vegetation during his descent along the western flank of the Sierra San Pedro Mártir, and his route is unclear. His statement that "the way...was gentle and free from stones" suggests that they may have crossed a break in the western escarpment near the modern road to the observatory. He stopped at a place called La Concepción, a place-name still attached to Cieneguita de Soto, at an altitude of 1,900 meters just north of the road (Plate 20). From there to Mission Santo Domingo, a distance of 50 kilometers, he saw "the same kinds of vegetation [seen] on the other approach by Valladares [his ascent of the range]." These were coastal sage scrub or maritime desertscrub and chaparral, which are distributed throughout the foothills of the western slope.

ARRILLAGA'S FIRST JOURNEY: TO SANTA CATARINA (1796)

José Joaquin Arrillaga's first journey in July 21-27, 1796, surveyed the lands in the immediate vicinity of the prospective mission site at Santa Catarina. To reach his distination, he crossed the transverse range to San Pablo then a broad plain to Santa Catarina. After inventorying the lands surrounding the mission, he returned to San Vicente by way of Valle la Trinidad (Map 2B; Table 9).

Table 8. Tree circumferences in three one-acre plots in mixed conifer forests of the Sierra San Pedro Mártir

Mixed Jeffrey pine plot 1			Mixed Jeffrey pine plot 2			Mixed white fir plot 3		
Tree	Circ. ft.	in.	Tree	Circ. ft.	in	Tree	Circ. ft.	in.
1.	6	7	*1.*	12	1	*1.*	10	8
2.	6	2	*2.*	11	9	*2.*	9	6
3.	8	6	*3.*	11	11	*3.*	8	8
4.	8	0	*4.*	5	1	*4.*	7	4
5.	10	1	*5.*	8	5	*5.*	8	8
6.	6	10	*6.*	10	10	*6.*	6	8
7.	4	8	*7.*	10	8	*7.*	8	8
8.	8	2	*8.*	6	0	*8.*	7	4
9.	12	6	*9.*	3	4	*9.*	9	2
10.	7	4	*10.*	6	9	*10.*	5	4
11.	12	11	*11.*	11	0	*11.*	9	9
12.	8	7	*12.*	11	0	*12.*	8	2
13.	7	10	*13.*	15	6	*13.*	9	9
14.	12	8	*14.*	5	3	*14.*	11	8
15.	8	11	*15.*	12	4	*15.*	17	9
16.	11	1	*16.*	11	6	*16.*	12	7
17.	10	2	*17.*	9	0			
Average Diameter								
	3	0		3	3		3	0

Source: Lower Californian, March 29, 1888.

From his home base at San Vicente, he took an arroyo to the northeast (Cañon Agua Caliente/Cañon Dolores). He saw "willows, poplars [*Populus fremontii*], and an occasional alder [*Platanus racemosa*], that would be useful only for minor projects," similar to riparian forests seen in other arroyos of the coastal range seen by Crespi, Serra, and Longinos-Martínez. Today, the arroyo, which drains a large section of the rugged transverse ranges, is a braided rocky wash with widely scattered trees.

During his ascent of the transverse ranges to the plains of El Alamo and Santa Catarina, Arrillaga described a general zonation of brushlands in which unidentified shrublands at lower elevations were replaced by chaparral dominated by *Adenostoma fasciculatum* and *Arctostaphylos* spp. above 1,000 meters. The lower arroyo, now covered with coastal sage scrub, was described as "bare hills with little or no grass."[4] After leaving this arroyo, "which headed east" (Cañon Dolores), Arrillaga proceeded northward along another canyon, which "ends at the foot of the large mountain range" (Cañon San Lorenzo). During his climb of the transverse range, he saw "some reed and **madroño**, and a scattering of oaks {**encino**}." The use of **madroño** described chaparral dominated by *Arctostaphylos* spp. The "wild reed" {**caña**} may be referring to a chaparral plant. Traditionally, the term refers to a slender tall grass, such as tule [*Scirpus acutus*]. Also, the term *cañada* is literally a place were **caña** [reed] grows; thus this statement may refer to bottomland vegetation; however, tule would not be expected to grow on the dry mountain slopes described by Arrillaga. The name could also refer to a tall, slender woody perennial such as *Fraxinus trifoliolata*, or to the less plausible alternatives, *Adenostoma fasciculatum* or *A. sparsifolium*. Although **caña** does not traditionally refer to a dicot, Arrillaga consistently uses the term "reed" with other chaparral descriptors, and thus appears to be describing a chaparral species. The oaks in the canyon were *Quercus agrifolia*.

The vegetation on the "summit of the sierra" (crest of the transverse ranges) was "the same as that on the slope" (i.e., **madroño**, *Arctostaphylos* spp.). To the north Arrillaga had a "pleasing view of small hills, canyons, oak trees and wild reed." He described San Pablo as having "many oaks and abundant pasture." San Pablo today is a large meadow surrounded by large groves of *Quercus agrifolia*, which in turn are surrounded by chaparral.[5]

From the San Pablo, Arrillaga traversed northeastward across the plains of El Alamo and Santa Catarina. Here he saw pasture in "small valleys...because the ridges have little vegetation [forage], and this is mostly wild reed, pine trees, **madroño**, and other shrubs." Apparently, herbaceous vegetation in this basin was restricted to bottomlands, and chaparral with manzanita covered the hillslopes. The pine was almost certainly *Pinus quadrifolia*, which is now scattered throughout the plain, including the mission site of Santa Catarina.

The 1906 Biological Survey described this plain as a "brush-grown hill country" and alluded to the exploitation of the vegetation for fuel at the Alamo mine during the late

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[4]Arrillaga never made specific comments of coastal sage scrub or maritime desertscrub. Lower coastal slopes now covered by this community were usually described by him as "bare hills."

[5]During the El Alamo strike of 1889, oak groves and grassland were described at nearby La Poza, 7 kilometers northwest of San Pablo (*Lower Californian*, June 5, 1890).

Table 9. Summary of vegetation descriptions in Arrillaga's first journey to Santa Catarina (1796)

Dates of Journeys[1]	Traverse segment	Vegetation described
July 21	Ascent of Transverse Range to San Pablo	Chaparral, desert chaparral, riparian forest, oak woodland
July 22-24	Santa Catarina and surrounding mountains	Chaparral, desert chaparral, four-needle pinyon forest, Jeffrey pine forest, meadows
July 25	Santa Catarina plains and Valle la Trinadad	Chaparral, desert chaparral, grassland
July 26-27	Descent of Transverse Range to Los Cochis and San Vicente	Chaparral, oak woodland, coastal sage scrub

[1] For detailed route information, including place-names and latitude/longitude coordinate data, see Map 2B and Appendix B.

nineteenth century. They found that "most of [the] plain and adjoining hills are covered with a fairly abundant growth of junipers [*Juniperus californica*] and some pinyon pines, but most of the larger growth for a dozen miles around [the mine]... appears to be approaching exhaustion" (Nelson 1921:16). Arrillaga's oversight of *Juniperus californica* there may be a general omission. He did not recognize this species at all in his diary.

Arrillaga spent several days examining the eventual mission site (Plate 21) and provided a relatively complete list of the important species at Santa Catarina, with emphasis on the ethnobotanical plants. He stated that "the Indian inhabitants...have many wild seeds such as **mezcal**, **dátil**, **zimarrón**, pine, prickly pear and several others." The **mezcal** is *Agave deserti*. **Dátil** in most of Mexico would refer to date palms (Martínez 1947:150; Tiscareño and Robinson 1969:100), which do not occur here. In addition, the missionaries of northern Baja California consistently used "**palma**" to describe Washington fan palm and blue fan palm oases. We believe that **dátil** was a recognition of the arboreal stem-succulent Mojave yucca (*Yucca schidigera*), whose foliar arrangement and fruiting structures resembles that of palms. Arrillaga consistently used the term **dátil** in areas where *Y. schidigera* is common. **Zimmarón** (= **cimmarón**) referred to a plant that is "wild and unruly." The best candidate at this site is *Acacia greggii* (Catclaw, **uña de gato**), which grows abundantly at Santa Catarina. Prickly pear is a platyopuntia, most likely *Opuntia basilaris*.

Orcutt (1889) gives a more complete, but similar, accounting of the El Alamo Plain. His list includes a number of chaparral taxa including "*Adenostoma sparsifolium*, *A. fasciculatum*,

a species of lilac [*Ceanothus*], oak-leaved cherry [*Prunus ilicifolia*], the sugar tree [*Rhus ovata*], and manzanitas [*Arctostaphylos* spp.], and two scrub oaks (Quercus pungens) [= *Q. berberidifolia*] and (Q. palmeri)." The California juniper [*Juniperus californica*] "was the most important shrub near the El Alamo mine." (Perhaps Orcutt observed it before it was cut for mining.) He also saw coastal sage scrub species that were attractive to honey bees, including "white sage [*Salvia apiana*], buckwheat [*Eriogonum fasciculatum*], and *E. wrightii*, as well as, the wild almond [*Prunus fasciculata*]." Great Basin sage [*Artemisia tridentata*] was seen on basin floors. Among succulents, he found "a species of Echino cactus [sic—possibly *Echinocactus polycephalus*], a wild tuna [*Opuntia basilaris*], a cholla [*Opuntia cholla*], the wild date (*Yucca baccata*) [=*Y. schidigera*], coyote plant (*Y. whipplei*), and *Nolina palmeri*" (Plate 22).

Arrillaga made three short day-trips from his main camp at Santa Catarina into the nearby Sierra Juárez. His first reconnaissance went northward 5 or 6 leagues (25 kilometers) along an arroyo that "first headed northeast but eventually east," clearly identifying the watercourses of El Tule and Las Palomas. A "pine forest with trees of all sizes" [perhaps both *Pinus quadrifolia* and *P. jeffreyi*], as well as "good patches of pasture," were seen in the upper canyon. Arrillaga provided more detail on this arroyo two months later during his third journey. His second day-trip went 1 1/2 leagues (10 kilometers) "to the north and northeast" from Santa Catarina and took him along Cañada el Rincón within the mesas of the southern Sierra Juárez. He saw no pasture in this arid country but did find "pine trees of all sizes," possibly small *P. jeffreyi* forests now seen in the northern tributary of this drainage, as well as pinyon forests. Since he also "arrived at a high point," perhaps one of the mesas, Arrillaga may have seen a *Pinus coulteri* forest now found on the northern and southern mesas above Cañada el Rincón. His third day-trip from Santa Catarina took him to a pass he called Puertezuelo—a modern place name for a low saddle in the Sierra Juárez southeast of the mission site. From there he saw the desolation of the Sonoran Desert and writes that the region "did not appear to offer much" (for the establishment of a mission).

Arrillaga returned to Santa Catarina and after completing inventory of the site, his party marched southward across the plain of Santa Catarina and El Alamo for Valle la Trinidad. He concluded that the plain had "sufficient pasture" for livestock. Some pasture contained "wild flax," perhaps a grass with tall inflorescences. Thin exotic grassland presently occurs locally in the bottomlands (*Bromus tectorum*, *Erodium cicutarium*), but most of the area is covered by open chaparral with *Juniperus californica.* Arrillaga then crossed a pass through the transverse ranges, which he referred to as "some hills and broken ground...where the sierras unite [i.e., the Sierra Juárez and transverse ranges], most likely along the route of modern highway to Valle la Trinidad. At this pass, he listed the current dominant species of chaparral growing there, including "**chamizo**, **madroño** [*Arctostaphylos* spp.], **jojoba** [*Simmondsia chinensis*], and other shrubs of little consequence" (Plate 23). This is Arrillaga's first use of the term **chamizo** [or **chamiso**], a generic for rigid, leafy, evergreen shrubs in semi-desert regions (Tiscareño and Robinson 1969:100). However, in northern

Baja California **chamizo** applies specifically to chaparral dominated by *Adenostoma fasciculatum*.[6]

Arrillaga traversed westward along Valle la Trinidad to a site with a hot spring that he called Agua Caliente. There he gave a remarkably current list of chaparral species that grew on the "high Sierra San Pedro Mártir" to the southwest of the basin, including **chamizo**, **jojoba**, **islay** [*Prunus ilicifolia*], **dátil** [*Yucca schidigera*], **zimarrón** [*Acacia greggii*], and **mezcal** [*Agave deserti*]. Arrillaga also saw "wild flax" on the rocky slopes. The Biological Survey described Valle la Trinidad as an "open grassland in the lower part [the west side], with bushes on the sides and much cactus, [Mojave] yucca, agave, and other desert growth for miles of its upper end [the east side] and in the pass." At present, Valle la Trinidad lacks substantial herbaceous cover except at the west end. Desertscrub, including *Larrea tridentata*, extends westward from the desert plains onto the lower hillslopes of this basin.

Arrillaga's first journey then descended from Valle la Trinidad to San Vicente. The party first arrived at Los Encinos. This place-name fixes the location of the only grove of *Quercus agrifolia* within a radius of 40 kilometers between the transverse range and the Sierra San Pedro Mártir. Continuing west, Arrillaga describes altitudinal zonation of brushlands. From Valle la Trinidad to Los Encinos, he saw "chamizo and some grass." At Los Cochis there were some hills "having grass and some shrubs" (presumably coastal sage scrub). At San José, the hills were "covered with brush" (again coastal sage scrub).

ARRILLAGA'S SECOND JOURNEY: TO SAN FELIPE (1796)

The primary objective of Arrillaga's second journey was to determine the suitability of San Felipe as a port on the Gulf of California. He reached San Felipe by way of Mission San Pedro Mártir. The journey took the primary mission trail south from San Vicente to Mission Santo Domingo, then eastward to Mission San Pedro Mártir via a trail along Cañon Santo Domingo (Meigs 1935:149). The trail along Cañon Santo Domingo was also the route taken by Longinos-Martínez to Valladares, except that Arrillaga probably took the south branch of Cañon Santo Domingo to San Isidoro, and then went upslope to the mission. Arrillaga then descended the sierra along Arroyo el Cajón and crossed the desert to San Felipe. He returned by recrossing the desert to Paso San Matiás and Valle la Trinidad to San Vicente (Table 10).

It is unfortunate that Arrillaga wrote nothing of the landscape during his journey to mission San Pedro Mártir nor of the lands surrounding the mission during his two-week stay (Tiscareño and Robinson 1969). However, there was no mandate for him to retain a diary since the mission was already in place.

Arrillaga left the mission by undertaking a 15-kilometer trek to La Encantada meadow, which he described as a horse and cattle ranch. His account of this meadow is similar to Longinos-Martínez's assessment four years earlier, in that the basin was covered by "many pines, **madroño**, and oaks" (see p. 59). The oaks {**encino**}, which were not mentioned by

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[6] It is noteworthy that Arrillaga does not use the term **caña** hereafter in his diary, thus making us suspect he had originally meant it as a synonym for **chamiso**.

Table 10. Summary of vegetation descriptions in Arrillaga's second journey to San Felipe (1796)

Dates of Journeys[1]	Traverse segment	Vegetation described
August 2-6, 22	Mission Sierra San Pedro Mártir	Jeffrey pine forest, mountain meadow
August 23-28	Sonoran Desert between the Sierra San Pedro Mártir and San Felipe	Desertscrub, microphyllous woodland
August 29-30	Paso San Matías, Valle la Trinadad and retun to San Vicente	Desertscrub, microphyllous woodland, pinyon forest

[1] For detailed route information, including place-names and latitude/longitude coordinate data, see Map 2A,B and Appendix B.

Longinos-Martínez, are almost certainly *Quercus chrysolepis* growing with sparse pine forest above the meadow (Plate 15). Arrillaga climbed a nearby summit where he could view of the "Sea of Cortez, a spacious plain at the base of the sierra [Valle Chico], and the port of San Felipe." Tiscareño and Robinson (1969:fn.#44) surmise that Arrillaga climbed one of the three peaks of Tres Palomas (lat. 30°53 'N, 115°23' W), but this view is possible from a variety of locations along the eastern escarpment (Map 2 A; Plate 24).

From La Encantada, Arrillaga descended the eastern escarpment to the desert. After traveling "one and a half leagues of good trail" (5 km to the southeastern corner of the meadow), he struggled down the precipitous north branch of Cañada el Cajón (Tiscareño and Robinson 1969: fn.#45), possibly the route of Longinos-Martínez' ascent of the Sierra San Pedro Mártir from the desert in 1792. Arrillaga's observation that "two other arroyos joining the main one" after two leagues descent (10 kilometers) is consistent with the topography of this canyon.

After reaching Valle Chico at the base of the sierra, Arrillaga provided the most detailed descriptions of Sonoran desertscrub of the late eighteenth century. His names of desert plants, all of which are in current use, usually identify them to genus or species. Valle Chico

was an area "without any grass {**pasto**} and with no other shrub or tree except **gobernadora** [*Larrea tridentata*] and **palo adán**."[7] The latter name refers to *Fouquieria splendens*, the only representative of this genus in the upper gulf, and can be confused with *F. diguetti*, presently called **palo adán**, found in central and southern Baja California (Roberts 1989). After crossing Valle Chico, Arrillaga entered the arid Sierra San Felipe, which he found to be "nothing but rock of bad country," although "some trees of **ypúa** or **medeja**" were seen along an arroyo (Plate 25).[8] San Felipe, an area of mostly *Larrea tridentata* and *Ambrosia dumosa*, was even bleaker to Arrillaga, who "saw no pasture, and firewood is of poor quality...The mountains which protect the port are entirely denuded."

Arrillaga returned to the Sierra San Pedro Mártir *bajada* by riding westward across the Sierra San Felipe through Paso Buena Vista to La Salada de Santa Clara and Valle Santa Clara. After traveling "one half league's distance (2 to 4 kilometers)" from San Felipe, he saw the **copal** [*Bursera hindsiana*], his only record of this species. Nelson (1921) reported this shrub in the same area by the taxonomic name *Elaphrium macdougalii* and stated that this population is "one of the most northerly representatives of the copals." The present northern limit of copal west of the Gulf of California is near San Felipe, except for a few coastal outposts near the delta of the Rio Colorado (Hastings, Turner, and Warren 1972).

As Arrillaga approached the Sierra San Pedro Mártir, he saw for the next three leagues (10 kilometers) only "some **medesa** [*Cercidium floridum* or *Olneya tesota*], and grass {**pasto**}"; however, he suggested an increase in shrub diversity next to the range near San Elías (a location near Cañon Esperanza or Cañon Copal). At San Elías proper, he recorded several dominants, including "**ocotillo**, **medesa**, and some **mezquites** [*Prosopis glandulosa*]," but the latter species was "few in number." (**Mesquite** is restricted to watercourses exiting the range.) Between this site and La Salada de Santa Clara, he found that "there are enough trees...**medeja, palo verde**, and no pasture".[9] His allusion to the adequacy of trees suggests that microphyllous woodlands were denser adjacent to the sierra than toward San Felipe, as seen today. Near Arroyo de la Vieja (Old Woman's Arroyo)—a current place-name—the important trees listed by Arrillaga include **palo adán** [*Fouqueria splendens*], **ypúa**, and **palo verde**.

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[7]This entry is Arrillaga's only specific reference to the creosote bush, as he seems to have decided thereafter to restrict his comments to desert "trees," i.e., the larger members of microphyllous woodland. In his fourth journey, he indicates that "shrubbery" does not deserve taxonomic attention. References to common subshrubs such as *Ambrosia dumosa* and *Encelia farinosa* are entirely lacking.

[8]**Ypúa/dipúa**, **medeja/medesa** and **palo verde** all appear to be names for *Cercidium floridum*. In fact, he referred to it as a "tree that has no leaves." This species is both drought and winter deciduous. However, **medeja** also translates to "let-me-go" bush, i.e., a shrub with sharp, possibly fish-hook thorns. The name **alambre de púa** means "barbed wire," or "wire of barbs or thorns." Thus, these terms may also refer to *Olneya tesota*, which is the dominant arboreal shrub in this part of the Sonoran Desert.

[9]The use of both **medeja** and **palo verde** may be a distinction between *Olneya tesota* and *Cercidium floridum*, respectively.

The Biological Survey (Nelson 1921:17) provided a similar appraisal of desertscrub composition between "the base of the San Pedro Mártir Mountains to San Felipe Bay." One difference was their observation that *Pachycereus pringlei* "grows abundantly along the east base of the San Pedro Mártir mountains" (Nelson 1921:107), an apparent oversight on the part of Arrillaga and Linck. The species listed by the Biological Survey are the same as today, except for Mediterranean, Middle Eastern and north African exotics, such as *Bromus rubens*, *Schismus barbatis*, and *Brassica tournefortii*, which invaded the desertscrub in the 1970s and 1980s (Plates 26 and 27).

Arrillaga recorded an even larger list of shrubs in an arroyo leading into Valle la Trinidad, including "**ocotillo** and **palo adán** [a confusion for *Fouquieria splendens*], **cholla**,[10] **nopal** [*O. basilaris*], **mezcal** [*Agave deserti*], **ypúa** [*Cercidium floridum*], and other shrubs." Nelson's assessment (1921:17) of Valle San Matías includes "cactus [= *Opuntia* spp.], yucca [*Yucca schidigera*], mesquite [*Prosopis glandulosa*], ironwood [*Olneya tesota*], [and] covillea [*Larrea tridentata*]," as well as species listed by Arrillaga.

We find it significant that Arrillaga did not mention the occurrence of palms in the northern arroyos of the Sierra San Pedro Mártir because palms usually caught the attention of the Spanish explorers. It appears that the gap in the palm oases between the eastern escarpment of the southern Sierra Juárez and southern Sierra San Pedro Mártir existed then, as now.

Arrillaga returned to mediterranean vegetation at Valle San Matías. Near a pass dividing this basin from the Sonoran Desert he found "pasture, and on the south side one finds oaks and pinyons." At present the slopes south of the pass have local populations of *Quercus peninsularis*, several scrub oaks (*Q. cornelius-mulleri*, *Q. cedrosensis*), as well as *Pinus monophylla* and *P. quadrifolia* (Plate 28).

Arrillaga recorded a "wild fig" in the eastern plains of Valle la Trinidad. At first glance, this remark is puzzling because the subtropical genus *Ficus* does not occur in the northern peninsula.[11] He may have been referring to a wild prickly pear that resembles *Opuntia ficus-india*, a native Méxican prickly pear that had become widely naturalized in mediterranean Europe by the seventeenth century. Thus, *Opuntia ficus-india* would be recognizable to a Spaniard (see Aschmann 1966:53, ft.#43). The native pad opuntias in Valle la Trinidad are *O. basilaris* and *O. chlorotica*. Although *O. ficus-india* is now widely naturalized and hybridized with native congeners throughout Baja California (Wiggins 1980), it is doubtful that Arrillaga was observing hybrid populations at this early date.

After traversing Valle San Matías, Arrillaga crossed Valle la Trinidad to familiar country at Los Encinos and on to San Vicente, recording nothing of the vegetation.

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[10]The term **cholla** refers to species in *Opuntia* having cylindrical or "pencil- shaped" stems, possibly *Opuntia acanthocarpa*, *O. echinocarpa*, or *O. bigelovii*..

[11]*Ficus palmeri* grows as far north as latitude 26° in central Baja California (Wiggins 1980).



Plate 21. Graveyard at Santa Catarina with the southern Sierra Juárez mesalands forming a backdrop. Small meadow of willows and grasses is encircled by chamise and scattered *Juniperus californica*. Mesa at distant *left* is silhouetted by a rare stand of *Pinus coulteri*.

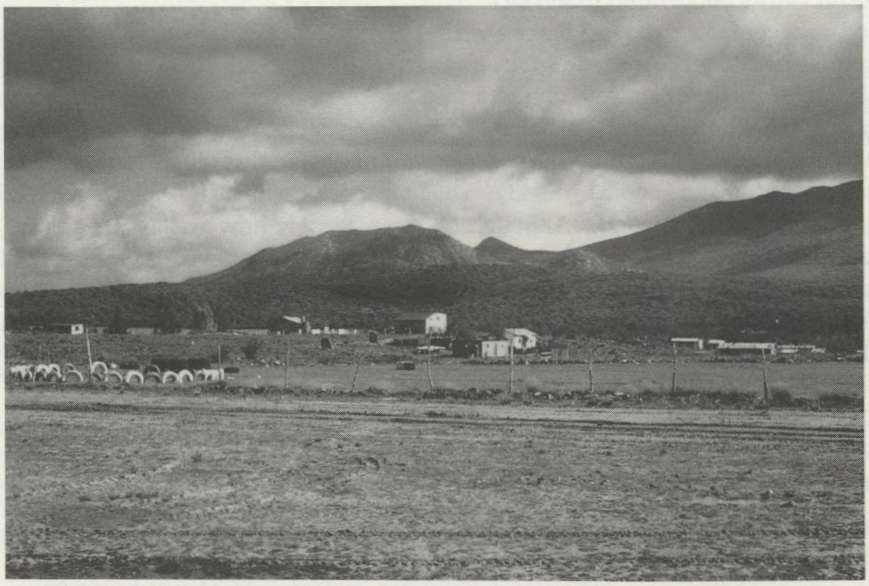


Plate 22. The settlement of El Alamo. Chamise and manzanita chaparral cover the nearby hills.



Plate 23. Narrow pass through the transverse range, Valle la Trinidad (*middle*), and the Sierra San Pedro Mártir plateaus in the distance. Arrillaga wrote that the chaparral here is dominated by **chamizo** [*Adenostoma fasciculatum*], **madroño** [*Arctostaphylos peninsularis*], and **jojoba** [*Simmondsia chinensis*], all occurring in the modern floristic composition. Infrequently seen species here include *Rhus ovata* and *Yucca schidigera*.



Plate 24. Vista from the crest of the Sierra San Pedro Mártir near the National Observatory toward Valle Santa Clara and the Sierra San Felipe. Dense *Pinus quadrifolia* forest in middle ground of the photo shifts to open woodlands of *Pinus monophylla* near the base of the range. In his second journey, Arrillaga had a similar vantage from the escarpment farther southeast, near La Encantada.

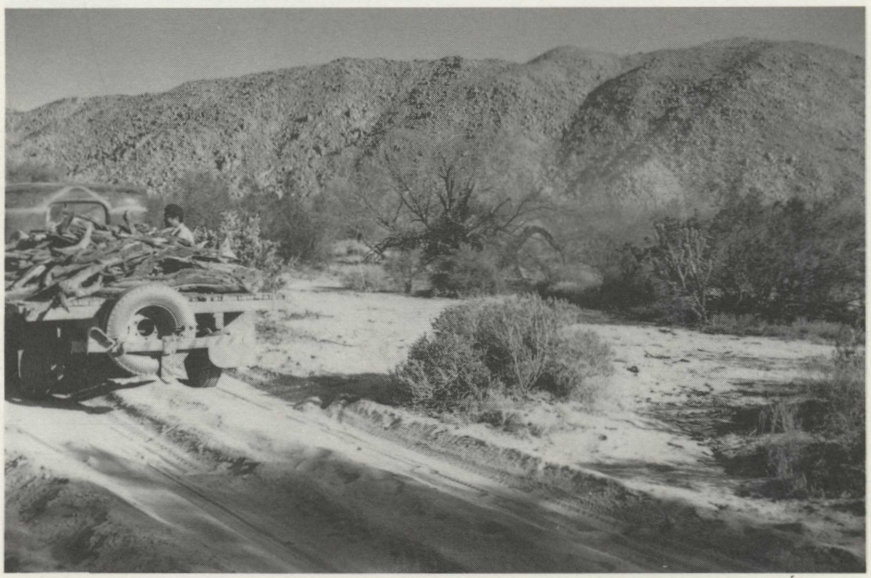


Plate 25. *Cercidium floridum* tree set on fire by a fuelwood gatherer whose truck broke down in a pass of Cañon las Cuevitas. Arrillaga traveled through this pass and described the same "trees" in this view, **medeja** (*C. floridum*) and **palo adán** (*Fouquieria splendens*).

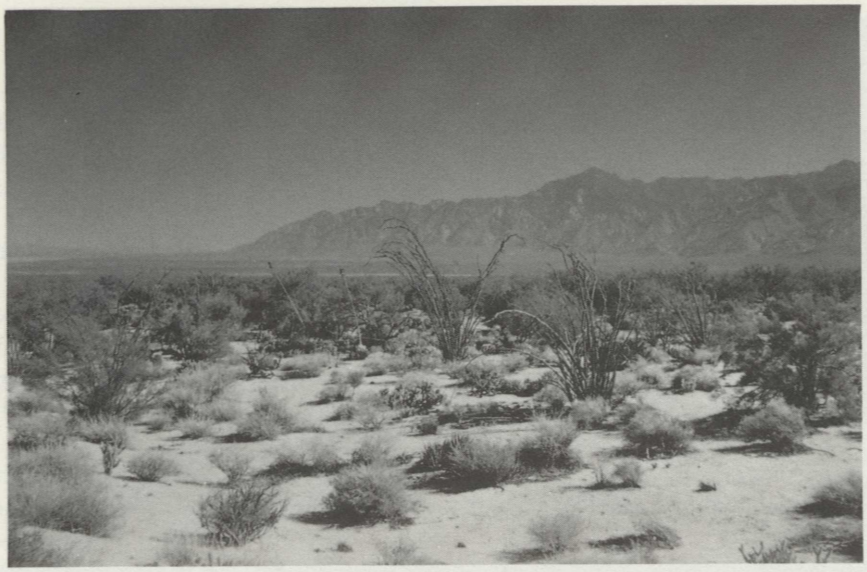


Plate 26. Valle San Felipe and the eastern escarpment of the Sierra San Pedro Mártir in 1969. High summit (*left center*) is Picacho del Diablo. Arrillaga described the arboreal shrubs seen here as **medeja** *(Cercidium floridum)* and **palo adán** (*Fouquieria splendens*). Other species here include *Olneya tesota*, *Agave deserti*, *Ambrosia dumosa*, and *Opuntia* spp.



Plate 27. Valle San Felipe in 1987 showing the recent invasion of two exotic annuals in the subcanopy, *Bromus rubens* and *Brassica tournefortii*.



Plate 28. Paso San Matías with *Pinus monophylla* in foreground. Arrillaga saw pinyon and oak (possibly *Quercus peninsularis*) on the south side of this pass in 1796. Photograph by Robert Thorne.

ARRILLAGA'S THIRD JOURNEY: TO THE SIERRA JUAREZ, VALLE SAN RAFAEL, AND VALLE GUADALUPE (1796)

On September 5-30, 1796, Arrillaga's third journey surveyed the Sierra Juárez north of the prospective mission site of Santa Catarina. From San Vicente, he undertook a roundabout path to the mission by traveling northward to near Ensenada, then eastward across Valle Ojos Negros, Sierra Juárez, and then making an excursion of the desert east of the mission. During his return trip, Arrillaga explored much of the Sierra Juárez, then rode west to inspect Valle Ojos Negros and Valle Guadalupe before returning to San Vicente (Maps 2B, 2C; Table 11).

Expedition to the mission. Departing Mission San Vicente, Arrillaga rode 30 kilometers north on the main trail of the mission system to Cañon la Grulla, which had been visited by Crespi and Serra in 1769 (Plate 11). He then climbed eastward along this canyon to El Salto, Valle el Pedregoso, and to a summit of the near-coast range near Tres Hermanos. From the summit Arrillaga stated that the "the Sierra [Juárez] is in plain sight and in between is a flat area" (the southern margin of Valle Ojos Negros). His diary records that Cañon la Grulla "had no trees...except for a few alders {**aliso**} [= *Platanus racemosa*] and oaks [*Quercus agrifolia*]," similar to other nearby watercourses seen by Crespi and Serra. Today this arroyo has local groves of riparian and oak forests although substantial stands of *Q. agrifolia* occur near El Pedregoso. He also indicated a regional separation between chaparral and herbaceous vegetation, stating that "the hills have pasture except where there is **chamizo**."

Once he entered the plateau south of Ojos Negros, Arrillaga first traveled along a "spacious plain, which becomes narrow at its end" (Arroyo Santa Clara). At El Porvenir, a plain east of Santa Clara, he found abundant chaparral with "lots of **chamizo**, **datil** [*Yucca schidigera*] and pine [*Pinus quadrifolia*]," possibly the three most important species now seen there. He then took another ravine and "came out in an area of large **chamizo** and some **madroños**" (probably near El Pescado). Arrillaga appears to indicate a change in chaparral species composition moving inland, as **chamizo** at Cañon la Grulla shifts to mixed stands of **chamizo** and **madroño** [*Arctostaphylos* spp.] on the higher plateau. The "large chamizo" may be his only specific reference to *Adenostoma sparsifolium* (a large chamise), a widespread shrub on the plains dividing El Alamo and Ojos Negros. Pinyon and pasture were seen at a resting site he called Jesús María, the modern Sangre de Cristo. Several groves of *P. quadrifolia* are found there. Arrillaga's general description of this basin is consistent with Orcutt's account of El Alamo (see p. 70).

The journey next surmounted the west slope of the Sierra Juárez "where timber had been cut for the Mission of Santo Tomás." To enter the range from Sangre de Cristo, Arrillaga first took a cañada to the right, "which has lots of tall grass..., gradually reaching the heights of the sierra." His route apparently followed an unnamed canyon to a place 5 kilometers east of Rancho la Choya, called El Tule. The vegetation along this route consisted of "pines, oaks and **madroños**." At present the chaparral there is dominated by *Adenostoma fasciculatum*, *A. sparsifolium*, *Arctostaphylos peninsularis*, *A. pringlei*, and *Ceanothus greggii*. Oaks found there include two trees (*Quercus chrysolepis* and *Q. peninsularis*) and two shrubs (*Q.*

Table 11. Summary of vegetation descriptions in Arrillaga's third journey to Santa Catarina (1796)

Dates of Journeys[1]	Traverse segment	Vegetation described
ROUTE TO MISSION		
September 5-10	Coastal road from San Vicente to La Grulla	-
September 11-12	Ascent of near-coast range	Grassland/forbfields, chaparral, oak woodland, riparian forest
September 12	Southern margin of Valle Ojos Negros	Chaparral, pinyon forest
September 13	Sierra Juárez to Santa Isabel	Chaparral, pinyon forest, Jeffrey pine forest, mountain meadow
September 14-17	Sonoran Desert along Arroyo Grande, Puertezuelo, and Santa Catarina	Desertscrub, microphyllous woodland, palm oases, desert chaparral
RETURN TRIP		
September 18-20	Ascent of Sierra Juárez to Laguna Hanson	Chaparral, Jeffrey pine forest, mountain meadow, pinyon forest
September 21-24	Descent of sierra to Valle Ojos Negros	Chaparral, Jeffrey pine forest, oak woodland, riparian forest, grassland/forbfields, microphyllous woodland
September 25-26	Sierra Blanca and Valle Guadalupe	Grassland, chaparral, oak woodland, riparian forest, Coulter pine forest
September 27-30	El Tigre to San Vicente	-

[1] For detailed route information, including place-names and latitude/longitude coordinate data, see Map 2A,B,C and Appendix B.

dumosa, Q. cornelius-mulleri). *Adenostoma fasciculatum* is significant on these slopes, but Arrillaga preferred to indicate the presence of *Arctostaphylos*. The pines are almost certainly *Pinus jeffreyi*, which is useful timber for the construction of a mission, such as at Santo Tomás.[12] *Pinus quadrifolia* occurs locally on brush-covered hillsides.

The Biological Survey made a similar description of the vegetation 10 kilometers farther north near the main road to Laguna Hanson: "The entire west slope of the Sierra Juarez range in this section is broken by long rounded, undulating ridges, rising so gently that for long distances we appeared to be traversing a slightly broken plain, covered with low brush and scattered rocks...Over these slopes a thin growth of small shrubs and widely scattered scrubby pines [*Pinus quadrifolia*] gave the landscape a poverty-stricken appearance" (Nelson 1921:15).

Arrillaga's party reached a summit (about 1 kilometer east of El Candado), then descended a drainage toward the east and "took another cañada...[to] his campsite he called Santa Isabel." This meadow, which retains this place-name, had "a lot of pasture," and [was] "surrounded by many pines, madroño, and oaks," similar to basins on the west side of the sierra. Arrillaga made a prophetic statement of this region's future economy, writing that "this site of Santa Isabel is appropriate for cattle in the summer, as well as all the territory which I covered the previous afternoon" (i.e., between La Puerta and Santa Isabel; Plate 29). From Santa Isabel to the eastern escarpment, Arrillaga described a transition from Jeffrey pine forest to more xeric vegetation cover dominated by pinyon pine [both *Pinus quadrifolia* and *P. monophylla* grow there], as well as **madroño** [*Arctostaphylos peninsularis*] and oaks [mostly *Quercus turbinella, Q. cornelius-mulleri*].

After a treacherous descent of the eastern escarpment along Cañon Santa Isabel, Arrillaga came to an oasis with an "infinity of palms," presumably the present-day *Washingtonia filifera* groves near the base of the range. The desolate nearby slopes were "nothing more than rocky ground and cliffs." Arrillaga identified "**mezcal** [*Agave deserti*] in places, and some worthless trees of **medesa** [either *Cercidium floridum* or *Olneya tesota*] and **mezquite**" [*Prosopis glandulosa*]. *Cercidium floridum* is common on the slopes and adjoining alluvial fans of Arroyo Santa Isabel, while *P. glandulosa* is restricted to wet places of the arroyo. In a short trek to the north, he saw "abundant **medesa** trees," but the pasture was good "only for a few animals."

From the Cañon Santa Isabel palm oases, Arrillaga rode 30 kilometers to the southeast along the broad wash of Arroyo Grande, which drains many catchments of the arid eastern escarpment of the southern Sierra Juárez. After crossing two mesas, he returned to the primary arroyo and traced it to the east base of the Sierra las Tinajas. From there he rode "west southwest in the direction of a prominent low point" (Portezuelo) of the Sierra Juárez escarpment. Arroyo Grande was covered by desertscrub with local palm oases on the eastern escarpment of the Sierra Juárez. The mesas and the main arroyo were covered with "a lot of

[12]In this part of his journal, Arrillaga typically refers to *Pinus quadrifolia* and *P. monophylla* as **piñon**, not **pino**.

ypúa [*Cercidium floridum*, *Olneya tesota*] and **palo adán**" [*Fouquieria splendens*] (Plate 30). Near the Sierra las Tinajas, he saw a little pasture of "**galleta**" [biscuit, most likely *Hilaria rigida*]. Otherwise, the region had no pasture "until one enters the mouth of Arroyo Agua Caliente...[which] forms a potrero [horse pasture]." According to Tiscareño and Robinson (1969:61), this upper arroyo has hot springs and a palm oasis at Rancho Agua Caliente. The pasture probably consisted of *Distichlis spicata* and *Hilaria rigida*. Arrillaga saw a "permanent ranchería" at this site, perhaps the Paipai settlement presently seen there (Gerhard and Gulick 1967). From this vantage he saw other palm oases to the south and east. Approximately a dozen canyons contain oases within Arroyo Grande.

To reclimb the Sierra Juárez, Arrillaga did not take the modern pass of Portezuelo along Cañon Alameda. Instead we believe he took Cañada Jamin immediately upstream from the settlement of Agua Caliente (cf. Tiscareño and Robinson 1969). This pass is a more direct route across the Sierra Juárez to Santa Catarina from Rancho Agua Caliente. Arrillaga noted a definite change in vegetation during his ascent: "The immediate mountains [surrounding Agua Caliente] are of rocky composition, without trees other than **mezcal** [*Agave deserti*] and **cholla** [*Opuntia* spp.]," but "on the upper half of the slopes...[he found] an abundance of **chamizo**, **mezcal**, **madroño**, and **jojoba**." Our vegetation map shows a transition from desertscrub to chaparral at 1,000 to 1,200 meters, approximately halfway from base of the escarpment (750 meters) to the summit [1550 meters]. The species listed by him are the modern dominants (*Adenostoma fasciculatum*, *Agave deserti*, *Arctostaphylos peninsularis*, and *Simmondsia chinensis*). Arrillaga also listed "**tabardillo**," a deciduous shrub described by Longinos-Martínez as "*Mimosa californica*" (Simpson 1961:24). However, this species is restricted to the southern half of the peninsula. Arrillaga seemed to be describing a leguminous shrub. He returned to Santa Catarina, repeating the route of his third sortie from the mission site (July 25).

Return trip through the Sierra Juárez. After making one final survey of the Santa Catarina mission site on August 18, Arrillaga "resolved to return to Santa Isabel, and to follow the Sierra northwards from there." This portion of the journey initially followed his first day trip from the mission (July 23)[13] by "skirting the mountains [northward]" from Santa Catarina. The party then ascended the arroyos of El Tule and Las Palomas until the latter drainage "bears east." Arrillaga then ascended the south slope of the Sierra Juárez to the basins of La Tableta and Santa Isabel.

His diary reveals that Jeffrey pine forests grew along watercourses and flat places, while chaparral covered hillslopes above—a pattern seen today throughout the Sierra Juárez. The details of plant cover along his route are striking:

> In this canyon [Las Palomas], the pine forest begins and continues along its entire length, until one leaves on the right and, ascending some hills, sees **chamizo**, pinyons, **madroños**, and some large loose boulders. But this lasts

[13] Arrillaga wrote [September 18] that "It is the same canyon of which I spoke when I came to explore the site of Santa Catalina."

only an hour and a half, and then one enters a beautiful pine forest with plenty of pasture at Santa Isabel.

In Cañon el Tule, the pine forests begin at 1,450 meters and extend eastward to the headwaters of this drainage, as stated by Arrillaga. To the north, he climbed hillslopes presently covered by chaparral dominated by *Adenostoma fasciculatum*, *A. sparsifolium*, *Arctostaphylos peninsularis*, and scattered *Pinus quadrifolia*. At La Tableta, he returned to a larger stand of Jeffrey pine and meadows, which continue north to Santa Isabel.

Arrillaga's journal indicates that pine forests become more extensive north of Santa Isabel, stating the his party "was always in a pine forest" during rides of 2 1/2 and 3 hours to "La Laguna" (Laguna Hanson, 25 kilometers from La Tableta). Because chaparral carpets the hillslopes, Arrillaga most likely followed the path of least resistance, along low points and in open pine forest. He probably took one of two routes: (1) through Potrero Murello and Potrero de Marcos, or (2) through La Botella and Arroyo del Saúz. Both routes have continuous Jeffrey pine forest as well as large meadows.

The expedition did not linger at Laguna Hanson because the lack of drinking water forced them to move two leagues (5 kilometers) north, where they could dig a well, and pitch camp. Arrillaga noted that this section of the sierra had "an immense pine forest with trees of all sizes, and...in all directions." Indeed, the Laguna Hanson stand is the largest one of the sierra (Plate 31). The Biological Survey passed through this site but was less extravagant in its assessment of this place. According to Nelson (1921:150), "Laguna Hanson is a shallow pond about half a mile (1 kilometer) across, situated in a small mountain park and surrounded by low growth of Jeffrey pine." The abundance of pine forest around this lake was also described by Lemmon, who reported to the *Lower Californian* (June 3, 1892) that the "bull pine of the Jeffreys [*Pinus jeffreyi*]...seems to be most abundant on the mountains east of the San Rafael Valley [Valley Ojos Negros] at an elevation of 4,000 to 6,000 feet."

From his camp, Arrillaga took a foray "two leagues northeast...then northward" from pine forest into arid scrub vegetation on the eastern escarpment. From the northernmost point of their route, they had a view "of the precipices of the sierra on the east side, very steep for a considerable distance, and forming on the north side a 'C.' " From this vantage, Arrillaga saw "only flat country, of clay, without trees" (the desert). The "C" shape may describe the headwall configuration of a major canyon on the eastern escarpment—concave eastward—Cañon el Carrizo or possibly Cañon la Milla (El Tajo). Here, Arrillaga described modern distributions in which the pine forests of the plateau give way to pinyon forest and chaparral toward the edge of the escarpment: "From the most northerly point I reached this morning the pine forest [*Pinus jeffreyi*] ceases to exist, and only bare hills are seen, with **chamizo**, **piñon**, and **mezcal**" [*Agave deserti*][14] (Plates 32 and 33).

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[14]Arrillaga appears to describe the extensive pinyon forests covering the plateaus north of his view near El Topo toward the international boundary. The broad distribution of pinyon forest in northern Baja California was known by the late nineteenth century. Lemmon reported in the *Lower Californian* (June 3, 1892) that "pinyon forests, composed of a nut pine (*Pinus parryana*, *Pinus quadrifolia*)...[begin] a few miles south of the boundary...and extend southward along the backbone of the peninsula, with only an occasional break, to

Arrillaga returned to camp and proceeded northwesterly to a stream at a place he called San Mauricio (present-day La Matanza). He was apparently impressed with this site, which he described as having "an abundance of pasture and pine forest of tall stout trees." La Matanza is one of the most verdant meadows of the Sierra Juárez, and the surrounding *Pinus jeffreyi* forests have rare populations of *Calocedrus decurrens* (Minnich 1987a).

Arrillaga descended the west slope of the Sierra Juárez to Valle San Rafael (Ojos Negros), and wrote perhaps the most graphic account of forests and chaparral from this period. Knowledge of his route is thus paramount in the interpretation of vegetation along this portion of the journey.[15] Fortunately, Arrillaga's directions and discussion of the terrain are relatively complete.

> [September 22]...[from La Matanza] I started out on the trail leading west. I went up a ravine and descended to an arroyo with many pines....I climbed a hill covered with an abundance of **chamizo**, and descended to another spacious sink, formed by several low hills....I continued along this sink, which was over a league long, and which had abundant pasture. Turning to the northwest [along this arroyo], I stopped...by some oaks...in a narrow place.
>
> [September 23]...Returning to the trail I left the previous day [i.e, where he turned to the northwest]...I entered a short cañada and after leaving it on the right, I went up the hillside. I crossed a mesa full of **chamizo**, from which I descended to a sink with sufficient pasture [and] some oaks....I proceeded to skirt [southward] along the flank of the mountain, descending to a narrow arroyo, where there are...a few pines. The [route that followed] was [covered by] **chamizo** and **madroño** and the entire view was the same....From this mesa I climbed onto another mesa, and others followed.... Since I left this morning our route has been toward the southwest, but then we directed ourselves toward the south until we arrived at the place they call the Arroyo of San Rafael, where all the cañadas and arroyos I crossed...come together.... [At this site] are cottonwood trees, willows, and sycamores. From La Laguna [Laguna Hanson] to this arroyo [it] is all downhill.

During a period of 1 1/2 days, Arrillaga had unquestionably crossed a series of ridges and canyons that fed into Arroyo San Rafael (the canyon of El Barbón), as seen in the aerial photograph mosaic in Plate 34. Arrillaga first trekked westward across three arroyos to La Rosa de Castilla, then southward about 10 kilometers along a low ridge to a point where all of these arroyos unite, near 31°58' N, 116°08' W. The route was entirely downhill. Some arroyos can be identified from his assessment of topography. The first arroyo is the upper headwaters of Cañon la Bandeja, immediately west of La Matanza. The second is the broad basin of Los Barrancos. The third is La Casa Verde which forms a box-end on the north,

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the south end of the Sierra San Pedro de Martir." It was also reported that "along the precipices overlooking the desert another Pinon pine (Pinus monophylla) maintains a precarious existence" (cf. Minnich, 1987a).

[15]Tiscareno and Robinson (1969:66-67) did not trace Arrillaga's route through this part of the Sierra.

where Arrillaga camped. The last is the next drainage west, La Rosa de Castilla. Arrillaga described several trends in the vegetation: (1) forests growing in the arroyos, as seen elsewhere in the Sierra Juárez; (2) chaparral dominated by **chamizo** and occasionally by **madroño** [*Arctostaphylos spp.*] growing on the intervening hillslopes; and (3) with decreasing altitude, the forest composition shifting from pines {**pino**} to oaks {**encinal**}. The higher arroyos (Cañon la Bandeja, Los Barrancos) are covered by Jeffrey pine forest, whereas lower ones (La Casa Verde, La Rosa de Castilla) contain mostly woodlands of *Quercus agrifolia* with scattered *Pinus jeffreyi*. Chaparral covering the hillslopes is dominated by *Adenostoma fasciculatum*, *Arctostaphylos peninsularis*, *A. glauca*, and *A. pungens*. Chaparral is ubiquitous on the lower slopes as suggested by Arrillaga's remark that "the entire view was the same" (Plate 35). The canyon of El Barbón today has riparian forests of *Populus fremontii*, *Platanus racemosa*, and *Salix* spp.

When the expedition reached the east margin of Valle San Rafael (Valle Ojos Negros), Arrillaga saw a "green sink with lots of grass, on the side of the Sierra," clearly modern-day La Huerta. This site had "no trees,...nothing but shrubs and a little grass" (Plate 36).[16] To the west of this site "about 1 1/2 leagues [5 kilometers]," Arrillaga saw a grove of "poplar trees {**alamo**}"—apparently the stand reported by Bernal several years before (Meigs 1935:32). This stand grows along arroyo El Barbón where it discharges into Valle Ojos Negros.

Arrillaga sent his party to the northwest side of this basin to pitch camp. In the meantime, he rode to the west side of Valle Ojos Negros "where the arroyos of San Salvador and Jesus María come together," then recrossed the basin to the northeast side where he found "a beautiful cottonwood forest." Arrillaga was impressed with the extensive herbaceous vegetation of Valle Ojos Negros, stating, "From both sides of these hills [i.e., the Sierra Juárez and the near-coast range], the pasture begins, with an abundance of tall grass {**pasto**} and tules." On the west side, he also referred to a "sink," apparently in reference to the large meadow on the west side of the basin, near the modern Rancho Buenos Aires.

The Rancho Buenos Aires "sink" is shown on a map of "Valle de San Rafael" near modern Ojos Negros, sketched in 1864 by Don Raimun (Plate 37). The map is consistent with Arrillaga's account of vegetation, as well as with the modern vegetation (Plate 38). Raimun showed a large "Sienega" [sic], or wetland, whose shape unmistakably identifies it as the meadow of Rancho Buenos Aires. The meadow is further recognized by its position immediately west of a linear hill identified as sierrita (little mountain), the modern Cerro Portezuelo. To the northeast of the cienega, a few small hills ("*lomas*," actually small interfluves) are depicted. Two small meadows to the south are named Ojos Negros—the present place-name of the basin—apparently because the dark wetland herbaceous cover resembles "black eyes" from a distance. Raimun's map also depicts two forests of **alamos**

[16] Nelson (1921:15) described La Huerta as "a little Indian village where...a small stream flows through the broad lower end of a canyon in the foothills of the Sierra Juarez. A dozen or more Indian families occupy a few huts scattered among small fields and orchards, where they grow peaches, apricots, corn, beans, and other garden vegetables."

[*Populus fremontii*]. The forest on the east side is the modern stand along Arroyo el Barbón recorded by Arrillaga from his camp at La Huerta. The other, north of the *cienega,* was possibly Arrillaga's "beautiful cottonwood forest." (Arrillaga's trek to the northeast side of the basin would take him past this grove.) To the northwest of the *loma*, Raimun sketched an area of "amayo sienegoso," now covered by wetlands and *P. fremontii.* The map also portrays **mesquital** [*Prosopis glandulosa*] at the east end of the *sierrita*. This shrub is presently abundant there. *Prosopis glandulosa* is also found west of Real del Castillo Nuevo.

Nelson (1921:15) gives a similar account of Ojos Negros: "The bottom of the valley is covered with grass and small scattered shrubs, the latter increasing in size and abundance in the bordering foothills on both sides." A mixture of mesquites, yuccas [*Yucca schidigera*], and other Lower Sonoran (desert) species were also seen at the south end of the valley. Where lands are not cultivated, this basin is now covered by exotic annual grassland, which gives place to chaparral on the adjoining hillslopes (Plate 39).

Arrillaga took a short foray into the hills northeast of Valle Ojos Negros. After crossing "an arroyo with many poplar trees," he saw "many rocky cliffs and extremely broken ground [Agua Caliente?], with some **chamizo** and **varejón**." **Varejón**, his first use of the plant name in his diary, refers to a species having the shape of a medium sticklike tree (Tiscareño and Robinson 1969). This is almost certainly *Fraxinus trifoliolata* which has a habit of upright, almost vertical stems. (*F. trifoliolata* is now called **vara blanca** meaning "white stick"). It is most common along the near-coast ranges at lower elevations but does grow as far inland as this site. Arrillaga then rejoined his party at the northwest end of Valle Ojos Negros (near La Rosa del Castillo Viejo).

The final leg of Arrillaga's third journey crossed the near-coast range of Sierra Blanca to explore Valle Guadalupe, 20 kilometers northwest of Valle Ojos Negros. Arrillaga first rode "west northwest...up a very difficult slope" and after crossing a high point of the range, he "descended a cañada of many oaks," apparently the large stand of *Quercus agrifolia* along Cañada los Encinos. During his descent to Guadalupe, Arrillaga refers to several chaparral shrubs including **chamizo**, **madroño**, and **varejón**. Today, chamise chaparral dominates this range, except on upper northern exposures, which are covered by *Ceanothus oliganthus. Arctostaphylos* spp. is restricted to the highest slopes. Halfway down to Valle Guadalupe, Arrillaga made reference to "a little cut timber of pine trees, belonging to Mission San Miguel." The occurrence of the stand to the "west of the trail" identifies the *Pinus coulteri* forest of Sierra Blanca, which covers about a hundred hectares near the eastern summit.[17]

When Arrillaga reached Valle Guadalupe, he saw "a strip of small Alder trees [**aliso**, *Platanus racemosa*]," a stand that can be seen today. He was impressed with the large size and open pasture on the east side of Valle Guadalupe. This basin is now mostly planted to vineyards, but open fields and uncultivated lands are covered with exotic annual grassland.

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[17] Only six small populations of *Pinus coulteri* covering 1,400 hectares, exist in northern Baja California today (Minnich 1987a), and it is remarkable that the Spanish diarists encountered any of them. Arrillaga passed west of this stand on Sierra Blanca, and possibly by others on the mesas above Cañon el Rincón (see Moran 1977). *P. coulteri* was not distinguished from other tall pines; however, it forms monospecific stands in northern Baja California, so the forests seen by the Spaniards are likely to be the same.

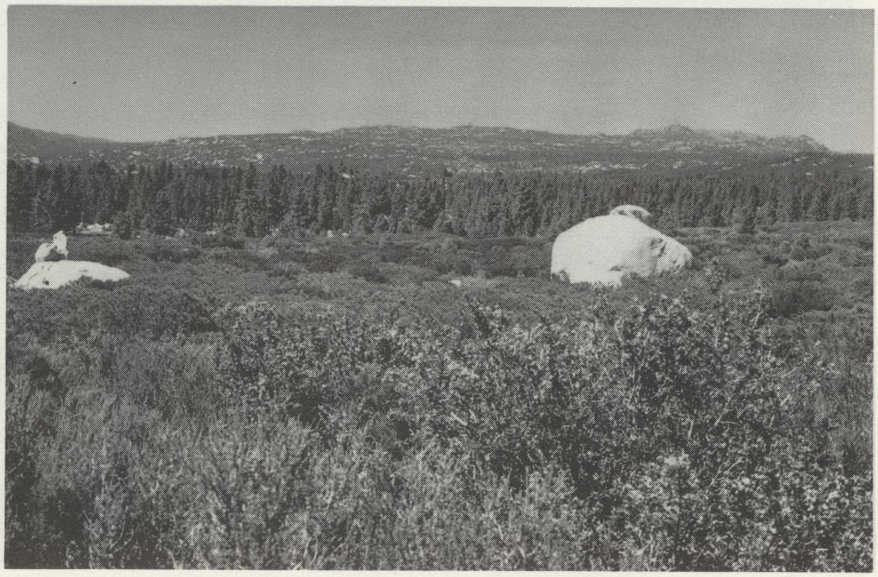


Plate 29. Jeffrey pine forest in a basin between Santa Isabel and Laguna Hanson. Chaparral (*Adenostoma fasciculatum*, *A. sparsifolium*, and *Ceanothus greggii*) carpet the surrounding hillslopes. Photograph by Robert Thorne.

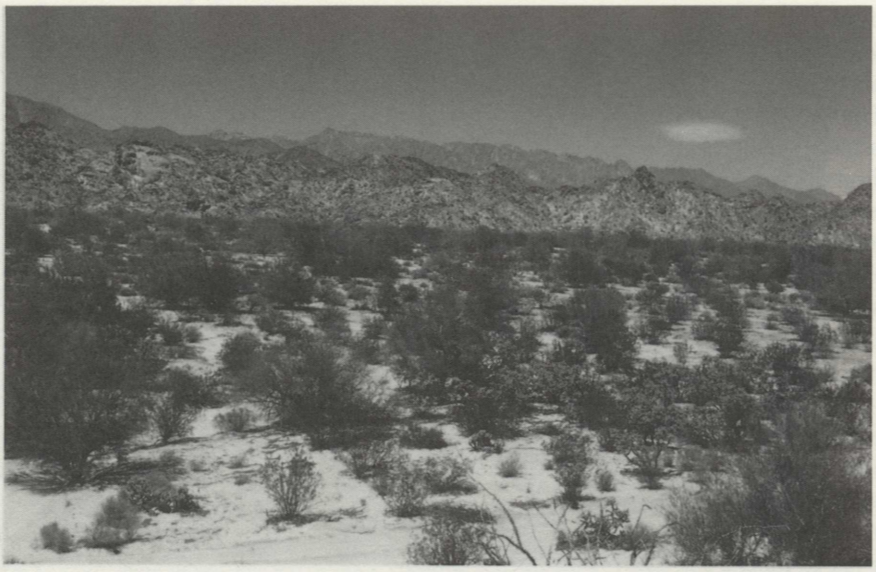


Plate 30. Desertscrub along Arroyo Grande. Creosote bush scrub grows with *Cercidium floridum*, *Olneya tesota*, and *Opuntia* spp.



Plate 31. Laguna Hanson encircled by Jeffrey pine forest. Arrillaga found the lake dry in 1796 but was impressed by an "immense pine forest." Photograph by Robert Thorne.



Plate 32. Cañon la Milla (El Tajo), the barren eastern escarpment of the Sierra Juárez, and the plains of Laguna Salada in the distance. This view was described by Arrillaga as "only flat country, of clay, and without trees." A gallery forest of *Brahea armata* grows in the depths of the arroyo.

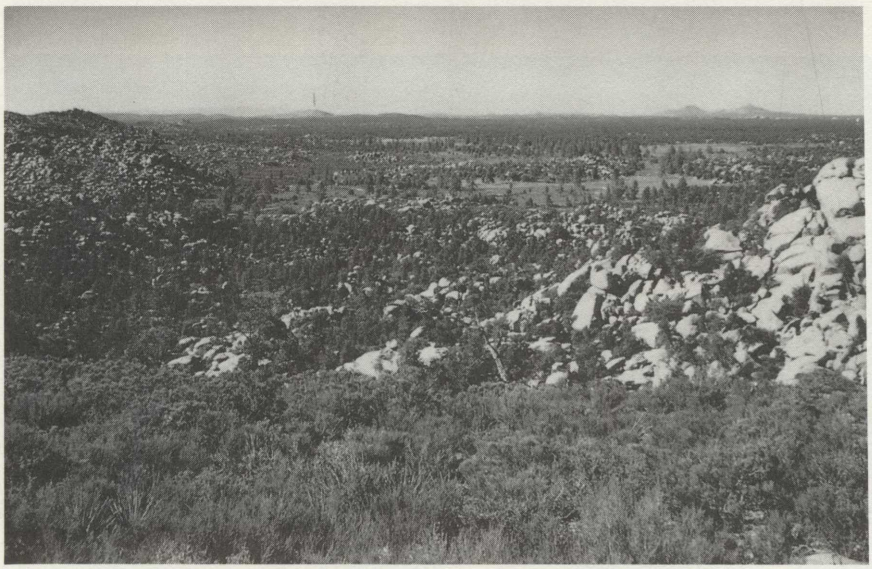


Plate 33. Pinyon forest on the La Rumorosa-El Topo plateau. Chamise and red shank chaparral cover the slope in the foreground. Viewing north from a high point about 10 kilometers southeast of this view, Arrillaga writes, "the pine forest ceases to exist, and only bare hills are seen, with **chamizo**, **piñon**, and **mezcal**. "

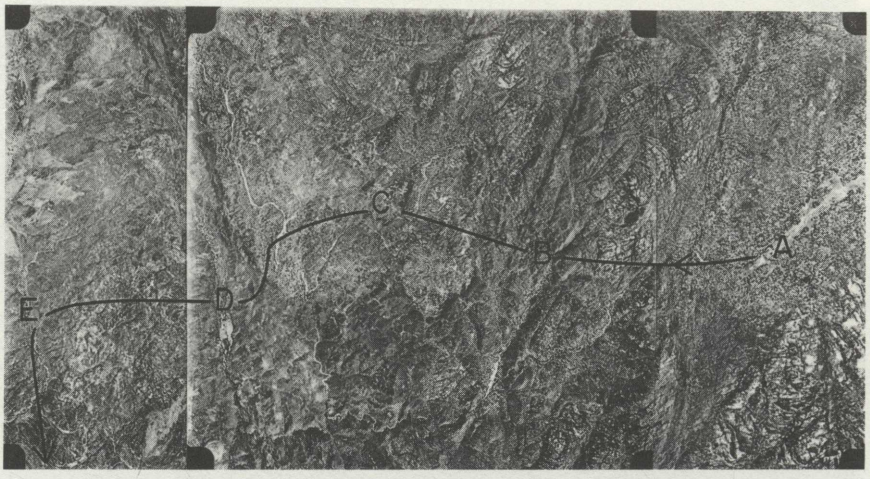


Plate 34. Aerial photo mosaic of Arroyo el Barbón, Arrillaga's probable descent of the Sierra Juárez toward Valle San Rafael (north toward top). Arrillaga rode west (*right* to *left*) from La Matanza meadow (*A*) and crossed a series of chaparral-covered ridges, and basins full of Jeffrey pine and *Quercus agrifolia* forests, including Cañon la Bandeja (*B*), Los Barrancos (*C*), La Casa Verde (*D*), and La Rosa de Castilla (*E*).



Plate 35. Chamise and manzanita chaparral in Arroyo el Barbón on the west slope of the Sierra Juárez. Two burns are seen in the middle ground. Chaparral is dominated by *Adenostoma fasciculatum* and *A. sparsifolium*, with scattered *Arctostaphylos glauca*, *A. peninsularis*, *Rhus ovata*, and *Salvia apiana*.

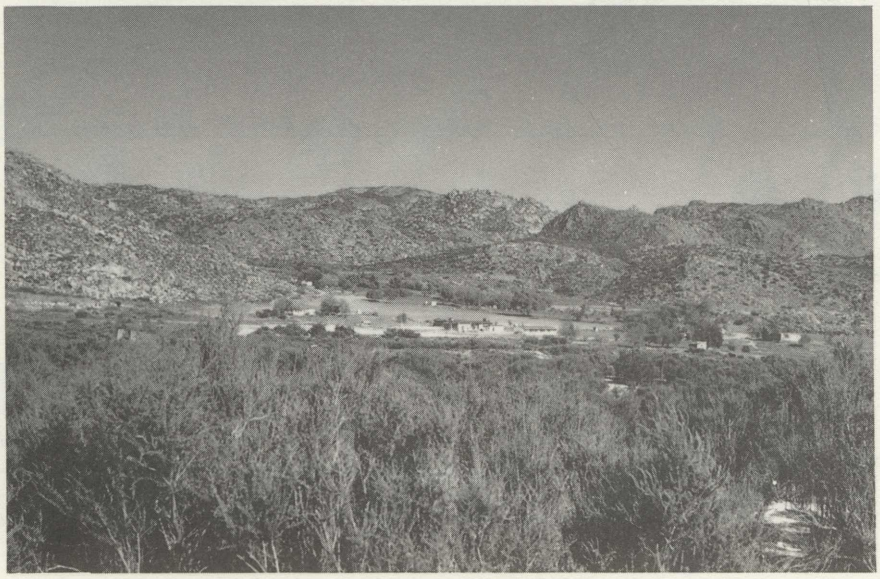


Plate 36. The Indian village of La Huerta, seen by Arrillaga in 1796 and Nelson of the Biological Survey in 1906.

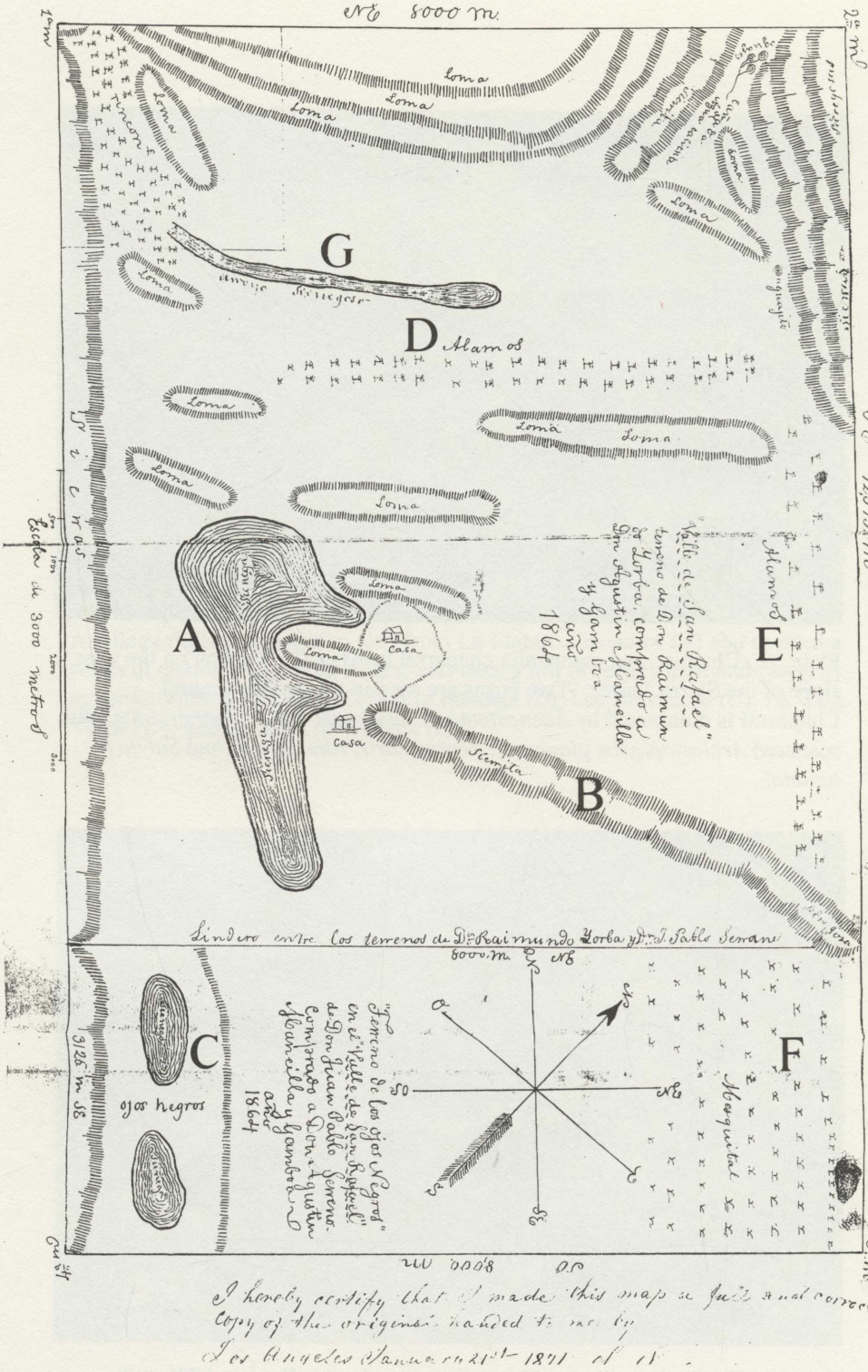


Plate 37. Map of Valle de San Rafael drawn by Don Raimun in 1864 showing a large "sienega" (*A*), a long sierrita (*B*, Cerro Portezuelo), and the Ojos Negros cienegas (*C*). Groves of "alamos" (*Populus fremontii*) are depicted to the north (*D*) and east (*E*) of the large cienega. Both groves follow Arroyo el Barbón. "Mesquital" (*Prosopis glandulosa*) is depicted on the east end of the "sierrita" (*F*). An area of "amayo sienegoso," a mixture of wetlands and *Populus fremontii*, is shown to the north of the primary cienega (*G*). (Zárate Archives, Ensenada, Baja California)



Plate 38. The same vegetation features as in Plate 37 can be seen in an 1972 aerial photograph of Valle Ojos Negros, including the large cienega (*A*), the long sierrita (*B*), the two meadows of Ojos Negros (*C*), the riparian forests of Arroyo El Barbón (*E*), the *Prosopis glandulosa* stand southeast of "sierrita" (*F*), and "amayo sienegoso" (*G*).

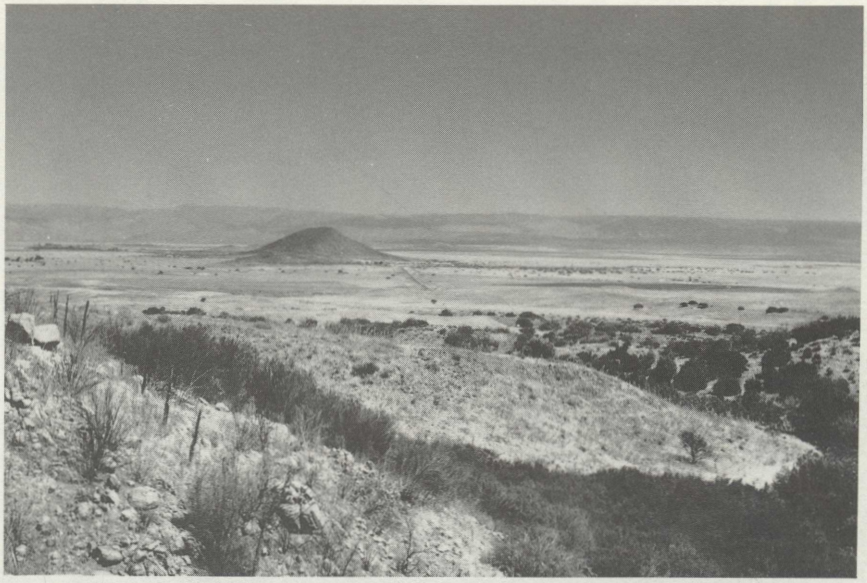


Plate 39. Valle Ojos Negros with the Sierra Juárez plateaus in the skyline. Arrillaga was impressed by extensive pasture in this basin, now largely dry-farmed for grain.



Plate 40. Vineyards at the east end of Valle Guadalupe and chaparral-covered Sierra Blanca behind. *Quercus agrifolia* woodlands cover the far side of the basin and *Pinus coulteri* forest silhouettes the left summit on the skyline. Arrillaga, Serra, and Crespi wrote that extensive pasture covered this basin, with oak forest bordering its extremities.



Plate 41. *Washingtonia filifera* oasis at Cañon Guadalupe, possibly visited by Arrillaga during his fourth journey.

On the northeast side of the basin he described an "impassable gorge" (Cañon el Burro) containing groves of *Salix*, *P. racemosa*, and *Populus fremontii* (Plate 40).

Arrillaga concluded the third journey by riding across Valle Guadalupe to San Marcos near the coast, then southward through present-day Ensenada to San Vicente, without further comment on the vegetation.

ARRILLAGA'S FOURTH JOURNEY: TO THE COLORADO RIVER AND SAN DIEGO (1796)

The primary purpose of Arrillaga's last journey, which spanned a period of two weeks from October 14 to October 27, was to explore the Colorado River. From San Vicente, his expedition traversed familiar territory from the mission to Santa Catarina. From there he marched through the pass at Puertezuelo into the desert where he encountered new territory at the Sierra las Tinajas (Maps 2B and 2C; Table 12).

Table 12. Summary of vegetation descriptions by Arrillaga's fourth journey to the Colorado River and along the eastern base of the Sierra Juárez (1796)

Dates of Journeys[1]	Traverse segment	Vegetation described
October 14-18	Sonoran Desert from Puertezuelo to the Colorado River	Desertscrub, microphyllous woodland, riparian forest
October 19-24	Desert along the east base of the Sierra Juárez north to the international boundary	Desert scrub, microphyllous woodland, palm oases

[1] For detailed route information, including place-names and latitude/longitude coordinate data, see Map 2B,C and Appendix B.

Arrillaga restricted his comments to Sonoran desertscrub, and all are consistent with the modern vegetation. An opening through the Sierra las Tinajas contained local cover of "**galletal** or **toboso**" [*Hilaria rigida*]. A well about 10 kilometers to the northeast near a sand dune field (Tres Pozos), was surrounded by "a few honey mezquites," apparently in reference to *Prosopis glandulosa*, or possibly *P. pubescens*. According to Arrillaga, the plain leading to this site—one of the most desolate stretches in the northern peninsula—had no pasture and even **palo adán** [*Fouquieria splendens*] was absent. Bare hills were seen farther

east (Sierra las Pintas) before the "cottonwoods {**alamo**} of the Colorado River were seen." Mesquite was also present along the Colorado River (Tiscareño and Robinson 1969:88), as well as between the river and Laguna Salada.

After a battle with Indians of the Colorado River, Arrillaga's party returned to the Sierra Juárez near Cañon Santa Isabel, a canyon he previously explored on September 16-17. Turning north from this site toward his destination of San Diego, Arrillaga entered a canyon he named Arroyo San Cristóbal, which "extends considerably into the Sierra" (either Cañon Guadalupe or Cañon La Mora), and contained a large palm oasis [most likely *Washingtonia filifera*] (Plate 41). The expedition then marched directly northward along the base of the sierra, "which is very steep and it forms an arch," accurately describing a gentle bend of the escarpment that faces eastward with a central axis near La Poderosa, a ranch immediately west of Laguna Salada. Arrillaga wrote that the land along this bajada is "without pasture [herbaceous cover]; only scattered **palo adán** and **medesa**." Other vegetation next to the sierra is referred to as "shrubbery," which refers to shrubs other than microphyllous woodland species, including small taxa seldom recognized by Spanish explorers. Today, the area is dominated by *Larrea tridentata* and *Ambrosia dumosa*, with *Cercidium floridum* and *Olneya tesota* along the washes and *Fouquieria splendens* on the mesas and desert pavements.

When the fourth journey approached the modern international boundary, Arrillaga noted "a large indentation in the Sierra [Juárez]...toward the northwest" (near Agua Grande and about 20 kilometers west of Jacumé), which permitted views of the sierra belonging to the San Diego mission, the Laguna Mountains. He wrote in his diary that the bajada had only "gravel" (desert pavements) and **palo adán** (*Fouquieria splendens*), possibly indicating the increasing desolation of the Sonoran Desert to the north.

5

EUROPEAN LAND-USE, NATURAL DISTURBANCE, AND VEGETATION CHANGE

The Spanish diaries are a valuable record of the vegetation of northern Baja California at several levels of resolution, from the broadscale distribution of ecosystems to species distributions. The diarists sometimes provide extraordinary detail on plant distributions, including relationships to altitude and terrain, that appear to coincide with modern distributions; examples include: the northern limits of copal at San Felipe, palms at Cañon Agua Caliente and San Pablo in the Sierra San Pedro Mártir, and mescal (*Agave shawii*) at El Rosarito, as well as the southern limit of *Juniperus californica* at El Salto, the lower elevation limit of pine forest beginning halfway between the lip of the plateau and La Zanja in the Sierra San Pedro Mártir, and the interdigitation of pine forest in basins and chaparral on ridges and mesas of the Sierra Juárez. Perhaps these examples of distributions are representative of other species and community types in the region.

At the broadscale level, Crespi, Serra and Linck recorded the shift between desertscrub of the central peninsula and mediterranean scrub in the Sierra San Pedro Mártir. Crespi and Serra described succulent sage scrub from San Telmo to San Rafael; pastures at San Vicente, Ensenada, and Valle Guadalupe; and chaparral in the western Sierra San Pedro Mártir and the near-coast ranges north of Santo Tomás. Longinos-Martínez depicted the general distribution of brushlands, pine forests, and meadows in the Sierra San Pedro Mártir. On Arrillaga's first journey, he described chaparral and *Quercus agrifolia* woodlands in the mountains northeast of San Vicente, pinyon forests in the plains of Santa Catarina, and pine forests in the neighboring Sierra Juárez. His second and fourth journeys describe desertscrub east of the Sierra San Pedro Mártir and Sierra Juárez, respectively. His third journey included descriptions of chaparral and *Quercus agrifolia* woodlands in the near-coast and transverse ranges southeast of Ensenada, of chaparral and pinyon forest along the southern rim of Valle Ojos Negros, as well as of pine forest in the central Sierra Juárez.

EVALUATING HISTORICAL VEGETATION CHANGES

A critical question is: How much vegetation change has occurred since the Spanish expeditions? The pace of vegetation dynamics can be intrinsically slow. In slow-growing and long-lived communities, the span of 230 years since the initial Spanish expeditions is brief for even short-term population changes. Older trees in the pine forests of the Peninsular Ranges have survived since the late eighteenth century. Many resprouting chaparral species seldom

experience fire mortality (Zedler 1981), and may be as old as the mountain conifers. Moreover, selection processes that result in changes in recruitment patterns require at least one generation to translate into mature phases of vegetation. Establishment into new territory involves other lag effects from long-distance seed dispersal (Davis and Botkin 1985).

To be sure, the distribution, floristic composition, and physical structure of plant communities have not been fixed owing to natural population turnover (recruitment and mortality), as well as to cyclical changes related to disturbances such as floods, attacks from insect pests, and fire. The vegetation of northern Baja California, being well adapted to periodic disturbance, would be expected to be stable despite continuous local change arising from disturbance (Shugart 1984; Pickett and White 1985).

The vegetation can also be altered by anthropogenic activities such as grazing, mining, logging, deliberate burning, and the introduction of exotic species. Efforts to distinguish vegetation changes arising from landuse or natural processes, however, are hard to separate, as exemplified by Bahre's land-use history of southeastern Arizona (1991); for example, the Spanish diarists wrote during a late phase of the little ice age (1550-1850), when the global climate, including that in temperate North America, apparently was cooler and moister than at present (Lamb 1977; Delcourt and Delcourt 1991; Bradley and Jones 1992). Evidences of climate change along the Pacific coast are subtle. In Alta California, glaciers in the Sierra Nevada were a little larger and more numerous during the Matthes interval than they are today (Birman 1964; Clark and Gillespie 1995). Long-term precipitation gauges at San Francisco, Sacramento, and Nevada City (beginning in 1849) show 10 percent greater annual precipitation in the nineteenth century than during the twentieth century. San Diego's precipitation record since 1850, however, shows no such trend (California, Department of Water Resources 1980). The Spanish diaries provide insufficient information to approach this problem: for example, the report by Crespi about *Platanus racemosa* at San Juan de Diós, 40 kilometers east-southeast of the present southern limit of the tree, may reflect a moist climate in the late eighteenth century. This, however, may also represent stochastic long-range, vicariant establishment in fragmented moist habitats by long-range seed dispersal that is typical of riparian species (Sauer, 1988).

The Spanish accounts of vegetation are also compromised by the imprecision of qualitative floristic data, and our relocation of the plants mentioned in the journal entries is frequently inexact. Hence, local changes during the past two centuries will escape detection by the comparison of these accounts with modern vegetation. From our site-specific analysis of Spanish accounts in northern Baja California, however, we conclude that with the exception of agricultural clearing, local anthropogenic disturbances, and the invasion of exotic annuals, the broadscale distribution, species composition, and local patterning of communities given at certain localities in the late-eighteenth century are not inconsistent with those today. Even the alien herbs have invaded former areas of herbaceous cover in a manner similar to that described in Alta California (Heady 1988). Today's vegetation, especially the brushland, forest, and desertscrub ecosystems, have remained largely pristine since the initial Spanish explorations.

LAND-USE HISTORY

The vegetation has a pristine character in part because the region's isolation has been responsible for a centuries-long delay in the development of agriculture and ranching after the Spanish discovery of the peninsula (see Henderson 1964). In the late eighteenth century, the Dominican padres conducted many enterprises with Native American farmers and ranchers, but these efforts resulted in localized subsistence agriculture and little immigration into northern Baja California. Livestock was preyed upon by Indians and herds were frequently decimated by recurrent drought. Mission documents indicate that in 1801 there were 7,255 sheep, 5,454, cattle, 1,109 horses, 940 goats, 266, mules, 140 hogs, and 10 asses in all of Baja California (Meigs 1935). *Quercus agrifolia* woodlands and riparian forests were exploited for timber and cordwood since the Mission period, but the extent to which the missions and ranches altered these forests during the past two centuries is unknown.

Cattle grazing remained the most significant economic activity through most of the nineteenth century. As the mission system disappeared, Dominican landholdings were granted or sold to local citizens, usually Mexican government officials and military officers, who began subsistence cattle ranching in the sierra. The gold strikes at the placers of Real del Castillo (Ojos Negros), El Alamo, Japá, Juárez, and on the west slope of the Sierra San Pedro Mártir between 1873 and 1890 (Map 2) resulted in increases of cattle and commercialization of cattle operations (Henderson, 1964; Chaput, Mason, and Loperena 1992).

Before the gold strikes, the region was unattractive for settlement. It was estimated that only 1,700 immigrants came to the peninsula during the colonial period (Henderson 1964). Even as late as 1857 the total population of Baja California was estimated at 2,872, mostly Indians (Henderson 1964). Native populations were doubtless larger, perhaps in the tens of thousands, although numbers had been in steep decline from precontact levels as a consequence of introduced European diseases (Aschmann 1959b).

The population increased with the expansion of agriculture during the dictatorship of Porfirio Díaz in 1877-1911 (Henderson 1964). During this period, much of the best land for agriculture, mostly grassland in the coastal valleys and desertscrub on the Colorado Delta, was cleared for crops. Dry farming of wheat and barley was successful in Valle Ojos Negros, in Valle San Vicente, and in the basins southeast of Tijuana. Still, the total population of the State of Baja California was less than 10,000 as late as 1910 (Table 13). Irrigation agriculture of stone fruits, citrus, grapes, olives, and vegetables was developed in Valle Mexicali at the turn of the century, and after World War II in coastal areas, including Ensenada, Valle Guadalupe, and parts of Ojos Negros, that had adequate groundwater from runoff from adjoining the mountains (Henderson 1964). The opening of the transpeninsular highway and Highway 3 between Ensenada on the west coast and San Felipe on the Gulf of California during the 1970s contributed to the rapid growth of agriculture at Valle la Trinidad, on the San Quintín coastal plain and at Valle San Telmo. Little farming has been practiced in the Sierra Juárez and Sierra San Pedro Mártir, except for local cultivation of potatoes, vegetable gardens, and fruit trees near ranchsteads (Henderson 1964). The total population of the State of Baja California has doubled every decade since 1930, reaching about one-half million by

1960 and 1.66 million by 1990 (Table 13). Most people migrated to the cities, characteristic of twentieth-century population trends in Third World and developing countries. The border states have experienced high immigration from other parts of México. Still, the rural areas have experienced only modest population gains, and most rural inhabitants live in the agricultural lands of Valle Mexicali. The rural population in the Tecate, Ensenada, and Tijuana *municipios* numbered perhaps 30,000 by 1960, with most people living in villages near the primary roads rather than making a living in the mountains. In rural areas of the Tecate *municipio*, which includes the northern Sierra Juárez, the population is 11,000, in which more than half are found in small towns near highways including Valle las Palmas, El Hongo, La Rumerosa, and Jacumé.

Today Baja California is mostly an unfragmented, wild landscape, with scattered patches of agriculture, reminiscent of the California landscape in the nineteenth century. Most mountain lands are effectively unoccupied other than for a few scattered, small ranches. The Sierra San Pedro Mártir epitomizes the extreme isolation of the region: for example, it was reported in the *Lower Californian* (December 26, 1890) that "no one at present lives on the mountain, [and that *vaqueros* live there] only in summer. Don J.M. Espinosa and family [lived]...fourteen years at the old [San Pedro Mártir] mission and kept their cattle there every winter." When Ed Griffin and a companion traversed the Sierra San Pedro Mártir in 1887, he claimed that "probably 5 white men [ever] set foot" in the area. He found "no trail or tracks," and they "frequently were obliged to cut a way through the dense brush. All [they] saw was a single trail along which the cattle moved up and down the mountain" (*Lower Californian*, May 9, 1890). A century later this range still has no permanent residents except for personnel at the national observatory. The Kiliwa and Paipai Indians live on the northwest base of the range (and in the neighboring southern Sierra Juárez). The Dominican missionaries had little success in bringing them into the mission system two centuries ago. Few Indians were available for the mission since much of the area was without permanent *rancherías*. Hostile Indians often raided the outposts, killing men and driving out cattle. The decimation of Indians by disease resulted in closure of the mission in 1806, it having operated only twelve years. The Kiliwa and Paipai Indians survive in isolation. At late as the mid-twentieth century, they spoke native languages and practiced nomadic hunting and gathering (Meigs 1935, 1939; Hinton and Owen 1957; Owen 1963; Tiscareño and Robinson 1969; Plates 42 and 43). Kiliwa informants explain that the forested plateau of the Sierra San Pedro Mártir was never permanently inhabited by Indians because of the winter cold (Meigs 1935, 1939).

LAND-USE IMPACTS ON VEGETATION

The single largest impact on the wildland vegetation of northern Baja California has been clearing for agriculture, mostly of desertscrub at Valle Mexicali, and of smaller areas of exotic grasslands and coastal sage scrub/maritime desertscrub in the coastal valleys. The total amount of land now under cultivation is 450,000 hectares, or 10 percent of the state north of latitude 30°. Wildland vegetation outside agricultural zones has been utilized as a source of

Table 13. Population data for Baja California.

	Baja California		Ensenada[1]		Mexicali[2]		Tecate[3]		Tijuana[4]	
Year	Total	Rural[5]	Total	Rural	Total	Rural	Total	Rural	Total	Rural
1900[6]	7,563	-	-	-	-	-	-	-	-	-
1910[6]	9,760	-	-	-	-	-	-	-	-	-
1920[6]	23,567	-	-	-	-	-	-	-	-	-
1930	48,327	22,059	7,071	4,029	29,985	15,143	-	-	11,271	2,887
1940	78,907	39,030	12,531	7.915	44,399	25,624	-	-	21,977	5,491
1950	226,965	80,574	31,077	12,928	124,362	59,753	6,162	2,481	65,364	5,412
1960	520,165	116,102	64,934	19,835	281,333	84,257	8,208	1,620	165,690	10,390
1990	1,660,855	315,061	259,979	90,554	601,938	163,561	51,557	11,317	747,381	49,629

*Sources:*Estados Unidos Mexicanos, *1963*. Estados Unidos Mexicanos. Secretaría de Programación y Presupuesto. Instituto Nacional de Estadistica, Geografía, e Informática (INEGI). 1983. X. Censo General de Población y Vivienda, 1980. Estado de Baja California. Vol 1. Tomo 2. México; Estados Unidos Mexicanos. Secretaría de Programación y Presupuesto. Instituto Nacional de Estadistica, Geografía, e Informática (INEGI). 1990. Baja California.Sociodemografico. XI Censo General de Población y Vivienda.

[1] Ensenada, Baja California S of latitude 32°, except the Sonoran Desert east of the Sierra Juárez and Sierra San Pedro Mártir.
[2] Mexicali, Sonoran Desert east of the Sierra Juárez and Sierra San Pedro Mártir.
[3] Sierra Juárez north of latitude 32° and east of Highway 2.
[4] Coastal Baja California north of latitude 32° and west of Highway 2.
[5] Settlements with rural political designations such as ranchos, *rancherías*, *ejidos*, and congregations, as opposed to cities (cuidad).
[6] Estadísticas Nacionales, 1957. Septimo Censo General de Población: 1950. Baja California Territory, Norte; p. 8, and data from files of the Oficial Mayor del Estado de Baja California.

lumber, fuelwood, and livestock forage. Whether these land uses have caused directional vegetation changes is not clear, but historical studies should be conducted to assess the potential consequences of past land uses, as well as the impacts from the modern, rapidly expanding economy. Brushlands and forests of northern Baja California are deliberately burned, but the impacts of this practice may be limited because these ecosystems are resilient under recurrent fire. The introduction of exotic species appears to have resulted in the largest vegetation changes outside the agricultural regions.

Livestock Grazing. Livestock have been grazed in the coastal valleys since the Dominican missions were established in the 1770s, but it was not until the mission system was extended inland to Santa Catarina and San Pedro Mártir in the 1790s that cattle were driven into the mountains for summer pasture (Henderson 1964; Haiman 1973; Freedman 1984; Meling-Pompa 1991a,b). The mountains were said to be well stocked ("carrying capacities" reached) by 1820 (Henderson 1964). Cattle numbers increased after 1850 as a result of growing markets for meat during the Gold Rush in Alta California. Americans also drove cattle from Alta California into the mountains on the Mexican side of northern Baja California. However, the number of cattle in the nineteenth century was apparently never very large (Henderson 1964). By 1857 there were 43 ranches in Baja California with 8,260 head of cattle marketed to California. The number of cattle marketed domestically is unknown but demand was apparently low until the gold strikes of the 1870s. It was estimated that cattle numbers in the Sierra San Pedro Mártir once reached 25,000 (*Lower Californian*, December 26, 1890). In 1911, after the Baja California gold strikes, there were reported to be 21,000 head in the Sierra Juárez and Sierra San Pedro Mártir (Henderson 1964). A census in 1940 reported that the *ejidos*[1] of northern Baja California had only 2,788 cattle, 1,497 goats, 1,794 mules, 8,006 pigs, and 714 horses (Secretaría de la Economia Nacional 1942).

In the nineteenth century, foreign investors began organized sheep drives, led mostly by Basque shepherds. The herds gathered in August near Tijuana and returned in October from as far south as the Sierra San Pedro Mártir (Henderson 1964). Grazing of sheep in Baja California intensified in 1910, when the practice was prohibited by the U.S. National Forest system in southern California mountain pastures (Lockmann 1981; Minnich 1988). Sheep were driven through public-domain and leased land, and wool was sold to a woolen mill at Ensenada. As many as 30,000 sheep per year were driven along this route between 1885 and 1905 to U.S. markets. Nelson (1921) reported that in 1906 large numbers of sheep were grazed on the west side of the peninsula as far south as San Quintín. However, sheep grazing has since declined in Baja California because the increasing agricultural settlement of coastal valleys has discouraged land-leasing to shepherds. Still, there were as many as 8,000 sheep in the Sierra San Pedro Mártir in 1956 (Henderson, 1964). Sheep were prohibited from grazing in the range beginning in 1964 (Meling Pompa 1991a,b).

It is unclear to what extent past grazing has affected northern Baja California's vegetation. Grazing has been blamed for a variety of destructive processes (Bahre 1991), including the destruction of the most palatable plants, changes in regional fire ecology, the

[1] Communal landholdings given out to citizens by the federal government after the revolution of 1910.



Plate 42. Petroglyphs within the territory of modern *Kiliwa* Indians, 10 kilometers northeast of Rancho Tepi in the northern Sierra San Pedro Mártir.



Plate 43. *Kiliwa ranchería* near Tepi in 1969. The trails leading away from the huts indicate continuing hunting and gathering activities, including the roasting of mescal and dátil.

destruction of riparian habitat, the spread of alien plants, and interference with the recruitment of shrubs and trees. Pastures were apparently in good condition during the nineteenth century. In the Sierra San Pedro Mártir, Ed Griffin in 1887 visited what he called the "small parks or meadows... scattered among the mountains" and stated that "the grass grew breast high" (*Lower Californian*, May 9, 1890). In 1888, Colonel D.K. Allen described "the pasturage" of the meadows in the Sierra San Pedro Mártir as "magnificent. The wild oats and rye, buffalo, bunch and other varieties of grasses were knee-high to the mules." In 1889 the forests around La Tableta, an area of the central Sierra Juárez that was to be logged by the International Colonization Company, contained "beautiful natural meadows... covered with good natural grasses fit for cutting for hay" (*Lower Californian*, August 1, 1889).

Cattlemen claimed that past sheep grazing begun in the late nineteenth century undermined the cattle-grazing economy due to the divergent management practices of sheep and cattle grazers (Meling-Pompa 1991a). Because sheep bite to ground level and were grazed in large flocks, it was asserted that the sheep damaged plant roots and removed young trees and herbaceous cover.

As in the early nineteenth century, cattle grazing is still practiced in the open range, as well as seasonal transhumance in the Sierra Juárez and Sierra San Pedro Mártir, and the same families have been in control of these mountain lands since the early nineteenth century (Meling-Pompa 1991a,b; Francisco Mayoral, personal communication). During the winter rainy season, cattle graze on annual herbaceous cover in coastal sage scrub and in exotic grasslands, as well as on feed crops in the agricultural zones. Once the annual grasslands have cured, cattle are driven to the mountain meadows during May and June, depending on rainfall the previous winter. The cattle are rounded up and herded up into the mountains in drives that last from three to ten days (Plate 44). The summer pasture provides 50 to 75 percent of the forage resource for cattle production (Meling Pompa 1991a,b).

Modern cattle operations are typically structured like that of the Bramadero *ejido* on the west slope of the Sierra San Pedro Mártir (Meling Pompa 1991a,b). This *ejido*, which covers an area of 300,000 hectares, is controlled by twenty to thirty commercial owners and is based near Sinaloa in the center of Valle San Telmo; it includes a number of dispersed satellite ranches to serve at way points for cattle drives: Santa Cruz, El Potrero, San Antonio, La Concepcion, Valladares, and La Suerte. These ranches are usually located near permanent streams and have developed rustic diversion systems to irrigate small areas of fruit trees and gardens.

Although the mountain meadows are the primary source of feed—estimated carrying capacities range from 2 to 15 hectares per animal per year (Henderson 1964)—the entire Peninsular Ranges are exposed to some degree of grazing and foraging as the cattle wander between the meadows, usually along cattle trails (Meling Pompa 1991a,b).

Estimates of carrying capacity made by Méxican range scientists in chaparral, pinyon forest, coast live oak forest, and Jeffrey pine forests at four *ejidos* in the northern Sierra Juárez vary from 20 to 50 hectares per animal per year (Table 14). Estimates are lowest in chaparral because most of the woody species are unpalatable. Along the international boundary east of Tecate, the carrying capacity is so low that livestock on both sides of the border depend almost entirely on irrigated pasture and/or supplemental feeding (Minnich and

Bahre 1995). Estimated carrying capacities in pinyon forest range from 30 to 34 hectares per animal per year. Range scientists indicate that pinyon recruitment was unaffected because saplings are not preferred browse (COTECOCA, n.d.). Most forests grow with chaparral, which is mostly unpalatable (COTECOCA, n.d.), and the abundant stands on the precipitous eastern escarpment would be difficult for cattle to negotiate. The best pasture are the widely scattered meadows in this ecosystem, where the estimated carrying capacity in pinyon is 15-20 hectares per head of cattle (Henderson 1964). Higher carrying capacities in coast live oak and Jeffrey pine forests are due to light herbaceous cover in the understory (Henderson 1964).

The hyperarid deserts of northern Baja California offer little forage for livestock, mostly brief flushes of spring wildflowers and shrub browse. Henderson (1964) stated that the dearth of grasses and forbs may force cattle to browse the foliage and bean pods of *Prosopis glandulosa* and *Cercidium floridum* and the flowers of *Pachycereus pringlei* and *Fouquieria columnaris*, and the fronds and seeds of fan palms. He estimated that carrying capacities there are 50 to 60 hectares per head of cattle, although they may be as low as 200 hectares per head of cattle. The pristine character of the deserts of northern Baja California contrasts with the intense exploitation of the desertscrub, mesquite woodland, and riparian forests of southeastern Arizona and adjacent Sonora, where overgrazing has degraded grasslands, reduced the importance of wildfire, and promoted invasions of *Prosopis* spp. and exotics such as *Tamarix* spp. (Bahre and Hutchinson 1985; Bahre 1991).

In the Sierra San Pedro Mártir, exclosures have been constructed for the period 1989-1993 to estimate the impact of cattle grazing on both forests and meadows (M.G. Barbour, personal communication). The intensity of grazing on the mountain varies from modest in the north, where meadows are small, to locally intense in areas surrounding the larger meadows of Vallecitos, La Grulla, and La Encantada. It has been found that cattle do not have a significant impact on the recruitment of conifers. Sapling counts at the Sierra Corona horse meadow and at an eight-year-old government exclosure (COTECOCA) at Vallecitos have failed to show consistent differences in sapling densities inside and outside their perimeter fences. Apparently, cattle do not eat conifers (Minnich et al. 1997). Exclosure experiments there reveal that cattle grazing in forests has no measurable effect on herbaceous and shrub cover in the forest, even though manure was observed outside the fences at all our sites. Cattle did have significant impact on the meadows at Vallecitos, but interannual fluctuations in biomass varied more with seasonal precipitation than with grazing pressure (M.G. Barbour, personal communication). Biomass was greater in the cattle exclosures than outside during all years by an average of 50 percent. The species composition within and outside exclosures, mostly herbaceous perennials (*Aster occidentalis*, *Eleocharis pauciflora*, *Trifolium wigginsii*, *Potentilla wheeleri*, and several species of *Juncus* and *Carex*), was not significantly different throughout the period. Excluding cattle for longer periods appears to favor the establishment of native bunch grasses, such as *Muhlenbergia richardsonis*. It is concluded that the meadows have been degraded to some extent in cover, biomass, and species diversity by cattle grazing; however, the rapid buildup in biomass after wet winters shows that the meadow species are very resilient.

It is possible that some meadow species at Vallecitos may have been extirpated during the past 200 years, but it is doubtful that herbaceous cover was ever verdant in a climate with

dry summers, except in the wettest meadows. For example, Longinos-Martínez did not mention the meadows when he passed through Vallecitos during the wet year of 1792, stating that the land was "without plants" [pasture].

Mining operations. Gold discoveries in northern Baja California between 1873 and 1889 attracted miners, mostly from California, and resulted in the establishment of several boom towns of 500 to 1,650 people each, including Japá, Tres Pozos (Juárez Placers), and El Alamo (Chaput, Mason, and Loperena 1992; Map 2). These strikes may have resulted in the largest buildup of population ever experienced in the mountains of Baja California.

At the El Alamo mine, gold was extracted from quartz veins (*Lower Californian*, August 1, 1889). The other gold discoveries were placers. The most enterprising effort was the rich Socorro placers, a large-scale hydraulic mining operation on the west slope of the Sierra San Pedro Mártir. During the 1906 Biological Survey, Nelson (1921) described a "large ditch" and "a well made trail" on the northern escarpment of the Sierra San Pedro Mártir. The purpose of the ditch, 18 miles (30 kilometers) long, was to divert waters of the Rio San Rafael to the El Socorro placers. It was constructed in 1893 by Harry Johnson, a resourceful miner from Texas, who built what was to later become the Meling Ranch (Rancho San José). By the end of the nineteenth century, gold was mined from several placers along the west edge of the Sierra San Pedro Mártir at such camps as Socorro, Valladares, Buena Vista, and Las Chollas.

Because nearly all of the gold discoveries were placers, the demands for fuelwood for such processes as smelting, running stamps, pumps, and ore crushers was limited (cf. Bahre 1991). Cordwood was a significant fuel for milling at El Alamo, where *Juniperus californica* was used for the smelting of ores in kilns (Nelson 1921; *Lower Californian*, August 1, 1889). The favored local species for heating and cooking may have been the same as those in southeastern Arizona—juniper, oak, as well as various chaparral species such as *Cercocarpus betuloides*, *Arctostaphylos peninsularis*, and *Rhus ovata*.

The exploitation of vegetation at these mines was brief. The best ores were taken quickly, and most of the placers played out within a few years of discovery (Chaput, Mason, and Loperena 1992); for example, the largest strike at El Alamo "had not panned out as well as expected" by 1889 (*Lower Californian*, August 1, 1889). Political and economic disruptions brought suspension of mining at the beginning of the Mexican Revolution, but thereafter placers were reworked at a small scale during 1920-1940 (Henderson 1960). The El Socorro mine was abandoned in 1912 after the Mexican government decreed that streams could not be diverted from one drainage to another (Held 1995). The utilization of fuelwood and timber probably exceeded local "carrying capacity" for only brief periods. Many other precious metal mines were low grade and never turned into paying operations (Chaput, Mason, and Loperena 1992).

Cordwood cutting for fuelwood. Although most of the population of northern Baja California was rural during the nineteenth century (Henderson 1964), the impact of woodcutting for domestic fuel was probably local and of little regional significance. The introduction and use of natural gas and propane for heating and cooking predate the population explosion that occurred after World War II in the border cities (Table 13). The

Table 14. Estimates of carrying capacities (ECC, ha/animal/year) at four ejidos in the northern Sierra Juárez

Vegetation type	ECC	Preferred browse
Ejido Sierra Juárez		
Red Shank Chap.	46	*Cercocarpus betuloides, Bromus*
Red Shank Chap.	50	*Bromus, Stipa, Erodium*
Coast Live Oak	22	*Juncus, Bromus, Sitanium longifolium*
Jeffrey Pine forest	25	*Bromus tectorum*
Pinyon forest	34	*Erodium cicutarium*
Jeffrey Pine forest	26	*Stipa, Aristida, Muhlenbergia, Sitanium, Erodium*
Pinyon forest	32	*Poa, Bromus, Stipa, Aristida, Sitanium, Erodium*
California Juniper	46	*Simmondsia chinensis, Prosopis, Acacia*
Ejido Jacúme		
Pinyon forest	30	*Bromus, Stipa, Festuca, Erodium*
California Juniper	43	*Simmondsia chinensis, Prosopis, Bromus,Stipa, Erodium*
Red Shank	43	*Cercocarpus betuloides, Bromus, Erodium, Stipa, Avena*
Ejido El Encinal (Tecate/Nejí)		
Chamise	50	*Cercocarpus betuloides, Stipa, Bromus, Avena*
Chamise	52	*Bromus*
Coast Live Oak	20	*Erodium, Bromus*
Ejido Baja California (El Hongo)		
Red Shank	50	*Cercocarpus betuloides, Erodium, Festuca, Stipa*

Source: COTECOCA, n.d.

greatest impacts may have occurred near Tecate, Ensenada, and Tijuana, where populations increased as early as the 1920s. Near Tecate and Ensenada, the chaparral cover is unusually thin and *Quercus agrifolia* woodlands at Tecate are nearly absent from suitable habitat within five kilometers of the city.

Logging. Historically, low human population densities and the inaccessibility of the pine forests have prevented significant removal of timber during the past two centuries. During the Dominican mission period, Arrillaga recorded in his journal that pine trees on the west slope of the central Sierra Júarez near San Salvador were cut for Misión Santo Tomás. *Pinus coulteri* forests were part of the territory under the jurisdiction of Misión San Miguel, but it is unclear whether this remote stand was ever exploited. Utilization of closed-cone conifer forests has probably been limited because most forests have been made inaccessible by

impenetrable chaparral with which it normally grows. The trees also make poor fuelwood because of their small size.

Pine forests were logged during the mining booms at Japá and El Alamo. The International Colonization Company built a road from El Alamo to the forests at La Tableta (25 kilometers south of Laguna Hanson) where the company constructed a steam sawmill with the goal to supply "10,000 [board] feet of lumber to El Alamo per day" (*Lower Californian*, August 1, 1889, May 9, 1890). Oxen were used for hauling logs to the mines. The La Tableta mill probably lasted only the few years of the El Alamo strike and had little impact on the forest there. The mill was still running three years later (*Lower Californian*, June 3, 1892) because it was reported that "the mining camp of [El] Alamo now obtains its main lumber supply from...the mountains east of the San Rafael Valley." This newspaper contains no later reports on the mill.

The *Ejido* Sierra Juárez established a gasoline sawmill at Arroyo del Sauz, 5 kilometers south of Laguna Hanson, in the 1930s, and ran a limited logging operation in the Jeffrey pine forests in the central part of the range. By 1940, a federal census states that 250 hectares of a total of 23,000 hectares of forest had been exploited. This *ejido* has not been active since the 1970s, and we could not find any information on how much timber was removed between 1940 and 1970. Studies in California have shown that clear-cut logging of areas greater than 2 hectares is incompatible with the health of Californian mixed-conifer forests because the development of mature stands depends upon the selective mortality of saplings and polesize trees rather than on commercially valuable old-growth trees (McKelvey and Johnston 1992). Removal of overstory trees leads to the establishment of dense, young-growth forests, increasing the potential for catastrophic canopy fires. The impact of the Ejido Sierra Juárez logging operation on forest structure may have been negligible. Only selective logging of old growth trees was practiced within a radius of 20 kilometers of the lake (Haiman 1973), and understory fires mapped from aerial photographs (Minnich and Chou 1997) have maintained open mature stands in these cutover areas.

The forests of the Sierra San Pedro Mártir have never been logged. In 1949, a primitive road was constructed from Rancho San Rafael to the northwest corner of the plateau. Another was built to near La Corona on the western rim of the plateau in the 1950s. These roads were constructed ostensibly to exploit the timber on the plateau, but logging was prohibited by the Parque Nacional de San Pedro Mártir before sawmills could be established (Henderson 1964).

NATURALIZATION OF EXOTIC GRASSLANDS

Human introductions, whether accidental or purposeful, can result in long-range colonization, especially if the new weedy species arrive in a habitat similar to that of its native range (Sauer 1988). Few woody species have successfully naturalized in northern Baja California, as is also the case in Alta California. The most conspicuous are mostly ruderal plants common to roadsides, such as *Ricinus communis* and *Nicotiana glauca* (Wiggins 1980). A few escapes have more generalized distributions. *Tamarix* spp. are becoming established at permanent wet sites and along moist arroyos. *Schinus molle* (California pepper), which is extensively

naturalized along dry washes, irrigated agricultural zones, and sites with urban runoff in California (Howard and Minnich 1989), is found in a few arroyos along the coast of northern Baja California as far south as Ensenada.

The most significant change in the vegetation of northern Baja California since the Dominican mission period is the invasion of several waves of exotic grasses and forbs, mostly from the Mediterranean basin and Middle East into herbaceous ecosystems, coastal sage scrub, and desertscrub (Burcham 1957, 1982; Heady 1988; Sauer 1988; Huenneke and Mooney 1989; D'Antonio and Vitousek 1992). In 1769, the Franciscan missionaries brought the first exotics that spread extensively in the Californias, notably *Erodium cicutarium*, *Avena fatua*, *Brassica nigra*, *Hordeum leporinum* and *Lolium multiflorum*; however, some of the earliest arrivals, for example, *Erodium cicutarium*, which is found in adobe bricks of the original mission foundations, may have arrived with the packing debris and hay of sixteenth-century voyages (Hendry 1931; Heady 1988).

Within decades of their arrival, the Franciscan exotics, especially *Avena fatua* and *Brassica nigra*, raced through suitable habitat in mesic parts of California (Sauer 1988). In southern California, these annuals were already abundant on the heavy soils of coastal valley floors and basins by the early to mid-nineteenth century. In 1812 dense cover of *Brassica nigra* was growing as high as a horse along the coastal plains between Los Angeles and the harbor at San Pedro, only four decades after its introduction by Franciscan missionaries (Burcham 1957).

In 1855, the U.S./Mexican boundary survey reported that in coastal valleys of southern California, "the wild oat *Avena fatua*...is so extensively naturalized, that it gives every fertile tract the appearance of a cultivated field. The wide plains that border the sea in the neighborhood of Los Angeles are covered with the richest pasturage. The Erodium cicutarium..., with several species of wild clover (*Trifolium* and *Medicago*) are mingled with a variety of other herbage, and thus serve to give a meadow-like aspect to this teeming land" (Parry 1859). *Avena fatua*, *Brassica nigra*, and *Erodium cicutarium* were reported by the Pacific Railroad Survey of 1855-1857 to be abundant on the floors of semiarid inland valleys of Alta California, such as the San Bernardino Valley and the Riverside/Perris Plain (Minnich 1988).

Orcutt (1886b) described exotics introduced a century before by Franciscan missionaries in bottomland habitats in northern Baja California. He noticed that mustard, very likely *Brassica nigra*, was used for construction of huts at in San Vicente, and observed a thin cover of filaree (*Erodium cicutarium*) established on heavy marine terrace soils at the agricultural colony near San Quintín in 1882, and east of El Rosario. He also noted *Trifolium* at San Quintín. William M. Gabb, in his report to J. Ross Browne in 1867, thought that the grassland in the uncultivated parts of Valle Guadalupe, apparently *Avena fatua*, was unsurpassed in any part of northern Baja California (Orcutt 1886a:37). *A. fatua* and *Brassica nigra* are now found in bottomlands in the coastal valleys east of Tijuana, in Valle Guadalupe, on the plains of Ensenada, and in Valle San Vicente. In 1861, José Matías Moreno wrote that in the pastures along the Pacific coast, "the most abundant [species] are oats, alfilerillo, trifolium and grass" (Piñera Ramírez and Martínez Zepeda 1984).

A second wave of introductions arriving in the late nineteenth century included *Bromus rubens*, *B. tectorum*, *B. mollis*, *B. diandrus*, as well as *Avena barbata* and *Brassica geniculata* (Heady 1988). Still other "third wave" taxa came in the twentieth century, including *Schismus barbatus*, a Middle-eastern grass that naturalized in the Californias during the 1950s. Many dominant second- and third-wave exotics have become established in dry, well-drained hillslope habitats beyond the range of Franciscan exotics, although the invasions seem to be less pronounced in the more arid climates south of Ensenada. Still, they are most extensive in former areas of herbaceous cover, in a manner similar to that described in Alta California (Heady 1988), although *Bromus rubens*, *B. diandrus*, and *Brassica geniculata* now form significant cover in coastal sage scrub. *Bromus rubens* and *Brassica tournefortii* are widespread in desertscrub (Minnich 1994a,b). Carrying-capacity surveys in chaparral and conifer forests at higher elevations of the Peninsular Ranges record scarce cover of *Bromus tectorum* and *Erodium cicutarium* (COTECOCA, n.d.).

The naturalization of second-wave exotics in Baja California is probably a twentieth-century phenomenon since *Bromus rubens*, *B. diandrus*, and *Brassica geniculata* were not recorded in North America until the 1880s. Anecdotal observations from southern California suggest a slow expansion of *Bromus rubens*, *B. diandrus*, and *Brassica geniculata* into the coastal plains by the early twentieth century. In the San Bernardino Valley 100 kilometers east of Los Angeles, for example, second-wave exotics were first recorded in 1890, but had only gradually expanded across the valley by 1920 (Parish 1920). *Bromus rubens* was not recorded in the Mojave Desert until the 1930s (Minnich 1994a,b). The initial expansion of these annuals through northern Baja California probably occurred during the same period, perhaps more recently. As a child, Ernesto Franco remembers wildflower fields south of Ensenada in the late 1950s. This area is now dominated by brome grasses.

In Baja California, as in California, the first exotic invasions preceded the arrival of scientifically trained observers, and the composition of native herbaceous cover is unknown. Widespread "pasture" and "meadows" were described by Spanish explorers at Valle San Vicente, Valle Santo Tomás, Ensenada Bay, and Valle Guadalupe, and on coastal terraces south of Tijuana. Arrillaga described grassland in Valle Guadalupe, as well as at the bottom of Valle San Rafael. Serra and Crespi crossed small pastures on the basin floors between the Sierra San Pedro Mártir and Valle San Telmo. These areas now contain large areas of exotic annual grassland.

The ambiguities of late-eighteenth-century Spanish diaries lend little insight on pre-European herbaceous vegetation. The frequently used term "**pasto**" does not mean "grassland," as has been conventionally translated, and it is uncertain to what extent graminoid species were seen by these explorers. Moreover, the composition of native herbaceous cover is unknown because exotic species supplanted native cover over extensive areas by the mid-nineteenth century. Phytolith evidences indicate that native herbaceous ecosystems in the California Central Valley consisted of perennial needlegrass (*Stipa* spp.) with diverse annual and perennial forbs (Bartolome, Klukhert, and Barry 1986; Heady 1988); however, nineteenth-century accounts of semiarid portions of the southern San Joaquin Valley suggest that Franciscan exotics may have displaced forb fields, with few annual grasses

(Wester 1975, 1981). Timbrook, Johnson, and Earle (1982) described a high diversity of herbaceous forbs in Chumash burials along the Santa Barbara coastal plain.

In the mid-nineteenth century, Parry (1859) described the vegetation in the valleys and foothills along the international boundary of California as having its "richest floral garb" during the spring. He wrote that "in February the moistened ground becomes arrayed in an assemblage of varied tints. The pale blossom of the elegant *Dodecatheon integrifolium* nod on every hill side, blue Lupines and rainbow colored *gilias* deck the ground...The rich yellow flowers of *Viola pedunculata* are abundant everywhere. A large number of *Hydrophyllaceae*, include species of *Nemophilia*, *Phacelia*, and *Eutoca*, are among the early tokens of spring, while the orange colored flowers of *Eschcholzia*, the pale blooms of *Platystemon*, and the pink ones of *Meconopsis*, show that the poppy family contribute largely to make up the vernal flora."

Orcutt's journeys, which took place before the arrival of second-wave exotics, indicated that the foothills and mesas at Tijuana, Ensenada, San Telmo Canyon, and east of El Rosario were covered by flower fields of *Eschscholzia*, *Lasthenia*, *Layia*, *Phacelia*, *Delphinium*, *Astragalus*, *Cryptantha*, *Perityle*, *Oenothera*, *Camissonia*, *Lotus*, *Calochortus*, and *Penstemon*. Orcutt did not mention *Stipa* or other native grasses.

Hypotheses concerning the naturalization of exotic grasslands can be distilled into two groups: (1) changes in disturbance pattern; and (2) competitive exclusion (D'Antonio and Vitousek 1992). The available evidence is not definitive.

Timbrook, Johnson, and Earle (1982), citing the accounts of Crespi, concluded that in the Santa Barbara coastal plain the elimination of deliberate burning with the demise of the Chumash Indians increased the fire intervals which in turn helped transform the fire-dependent native grasslands mixed with wildflowers to European annual grassland. Longer fire intervals were encouraged by early Hispanic and Anglo-American livestock grazing, which removed herbaceous fuels. Livestock grazing pressure may have selected for browse-resistant exotics, which had evolved under millennia of grazing pressure in Europe, over native herbs which evolved under light grazing in California (Sauer 1988). Livestock may have contributed to the expansion of exotic annual grassland by disseminating viable seeds in their droppings, hair and hooves and may have promoted weedy species by reducing the ability of native forbs and perennial bunchgrasses to compete with exotics (Bahre 1991).

The role of grazing in the expansion of exotic grasslands is not well understood. Exotic grasses and forbs, as well as native dicot wildflowers, recover quickly from grazing and fire because of their annual habit and survival of the seed bank; for example, grazing may protect coastal sage scrub from competitive displacement by stripping off exotics and increasing the bare zones necessary for the establishment of shrubs. Some invaders may have expanded through California without grazing pressure (Sauer 1988); for example there is evidence that mediterranean annual invasions preceded settlement in the Central Valley. Thus, competitive displacement may have occurred in this region without grazing pressure (Wester 1975, 1981). It appears that tough and weedy species from the Old World hit an "ecological vacuum" and spread rapidly into new territory (Sauer 1988). The impact of livestock in the spread of alien species was probably temporary. Although short-run processes such as livestock disturbance and agricultural clearing may have facilitated the spread of these exotics, in the long run their

distribution is related to their ability to displace native wildflowers and grasses in suitable, undisturbed habitat through competitive exclusion (Biswell 1956; Heady 1988; Huenneke and Mooney 1989; Huenneke et al. 1990).

The introduction of new taxa into a region is invariably associated with the decline of the native taxa because the resource base of habitats can support only a finite number of species (D'Antonio and Vitousek 1992). In the Central Valley of California, the invasion of exotics was encouraged by high levels of available nutrients and was independent of physical disturbance (Huenneke et al. 1990). Jackson (1985) suggests that nutrient-limited soils in the native Mediterranean basin limits most of these same exotics to being successional or ruderal species. But soils in the Mediterranean may be quite fertile (Barbour and Minnich 1990). Native dicots because of long seed life and because of discontinuous annual bursts of germination and growth cued to optimal conditions, much like desert wildflowers (Keeley 1989). Alien grasses, which are characterized by a short seed life and almost complete germination of the seed bank, develop heavy cover annually, with the potential of interfering with native dicot recruitment (O'Leary and Westman 1988; D'Antonio and Vitousek 1992). Perhaps closely related forbs in grassland and coastal sage scrub may have previously recruited continuously, as suggested by Orcutt's descriptions of widespread flower fields (certainly the entire region could not have burned the year he visited). The invasion of exotics may have since restricted natives to postfire succession sequences in which competition with exotics is reduced (Keeley 1989).

Climatic differences between California and the Mediterranean basin may also selectively influence exotic/native interactions (Minnich 1994b). Exotic and native herbs appear to have different phenologies related to selective pressures caused by the earlier onset of the rainy season in the Mediterranean basin (late September, October) than in California (November, December). Exotic grasses develop earlier than native herbs, establishing themselves rapidly after the first autumn rains, with moderate growth even during cool temperatures of midwinter. Native forbs also germinate with the first rains but display only limited growth during winter. They flush only by late spring, long after exotic species have formed dense cover. Native herbs appear to be favored only in years with late spring precipitation, mid-winter drought, or protracted drought, which either discourage or postpone germination of exotics until spring or cause them to perish before reaching flower during mid-winter dry spells. When exotics form thin cover, native wildflowers germinate, survive drought with limited mortality, reach flower, and produce seed despite adverse conditions.

WILDLAND FIRE

Recurrent fire is the most significant form of natural disturbance in northern Baja California, This is due to the region's mediterranean climate, in which winter precipitation is followed by dry summers (Plate 45). Fires continue to spread through coastal valleys, foothills, and mountains without human interference to this day, and deliberate burning is still practiced by *vaqueros* and farmers. Although fire control became official policy only by the 1960s, it has not been effectively practiced since that time (Freedman 1984; Meling-Pompa 1991a,b; Minnich and Bahre 1995; Minnich and Chou 1997; Minnich et al., in press).

Table 15. Newspaper reports of fire in northern Baja California

Year	Date	Comments	Newspaper Source
1871	November 23	Fires in the hills southeast of San Diego	(2)
1872	November 20	Fire from the international boundary east of San Diego to El Rosario	(2)
1879	June 7	Fire in Valle Guadalupe	(2)
1879	August 16	Big fire in Santa Cruz Canyon near Valle Guadalupe	(2)
1882	October 10	Extensive fire on Table Mountain (Sierra Juárez south of Laguna Hanson)	(2)
1890	June 12	Three day fire at Santa Rosa, El Tigre, and San Marcos	(1)

Sources: Lower Californian (1) and *San Diego Union* (2).

Historical data on wildland fire in northern Baja California before 1900 is scarce. Burning was seldom mentioned during the Spanish expeditions or by other early explorers. Crespi, Serra, and Linck passed through the area during the rainy season and during spring when vegetation was in full growth. During the Biological Survey, Nelson (1921) saw smoke rising daily from the fires of Indians living at Santa Catarina Mission. A search through the *Lower Californian* and *San Diego Union* yields only scarce, often anecdotal reports of fire in the mountains of northern Baja California (Table 15).

Fire-scar chronologies extending to pre-Dominican mission times at ten sites in the mixed conifer forests of the Sierra San Pedro Mártir revealed that ground fires occur at intervals of approximately 26 years (Burk 1991). There was no decline in the frequency of scars at the turn of the century as reported in many areas placed under fire suppression in the southwestern United States (Weaver 1974; McBride and Lavin 1976; Kilgore and Taylor 1979; Swetnam and Dieterich 1983; Swetnam 1993); however, it is unclear whether all fire-scar years reflect landscape-scale burns. Fire perimeter maps of the Sierra San Pedro Mártir for 1920-1991, which provide a more complete spatial picture of burning, give estimated fire intervals of 53 years (Minnich et al., in press). The disparity in fire-interval estimates may be related to site (point) sampling by fire-scar chronology studies (Johnson and Gutsell 1994). In most ecosystems, fires have characteristically long-tailed size-frequency distributions (Minnich 1983; Chou, Minnich and Dezzani 1993) such that any randomly selected sampling site has a greater probability of recording small burns than large ones. Thus, trees may be commonly scarred by local events of unknown landscape-scale importance. Fire-scar chronology methods may underestimate fire intervals because trees are scarred by abundant natural and anthropogenic ignitions that burn themselves out at a small size. Such burns also result in limited removal of biomass, camouflaging the relatively few large events that are

responsible for the fuel dynamics and population turnover of pine forests (Minnich et al. in press).

Fire perimeter maps give a more complete picture of the distribution and sizes of fires in northern Baja California after 1920 (Minnich 1983; Minnich and Chou 1997; Minnich et al., in press). Fires were numerous and small, varying mostly from 100-3,000 hectares. Burning was most extensive in coastal sage scrub and in chaparral of the mesic near-coast ranges and western flanks of the Sierra Juárez and Sierra San Pedro Mártir, as well as in mixed-conifer forests at the highest altitudes. Fires were widely scattered in semiarid desert chaparral and pinyon forests covering the eastern escarpments of the Peninsular Ranges. The fire rotation periods—the time required to burn an area equivalent to the total area of a vegetation type (Johnson and Gutsell 1994)—were relatively long, despite the absence of fire control, ranging from 50 to 70 years in chaparral and mixed conifer forest to more than 200 years in pinyon forest. No fires were found in desertscrub. The gradient in fire rotation periods appears to be related to gradients in climate, ecosystem productivity and fuel build-up rates (Knight 1987). Fuels build up fastest in fire-prone coastal slopes. Increasing aridity contributes toward lengthening fire intervals from windward to leeward slopes of the peninsular ranges.

Landsat imagery for 1972-1980 (Minnich 1983) reveals numerous small fires in coastal sage scrub and exotic annual grassland, but individual burns occasionally exceed >10,000 hectares. The largest burns may extend across a basin to the lower margin of mountain chaparral. Still, only 10 percent of the stands were burned during 1972-1980, giving fire rotation periods of about 80 years. Broad-scale burning rates in coastal sage scrub and grassland decreases southward with mean annual precipitation from the international boundary to the Sierra San Pedro Mártir.

Ignition sources versus system-regulation of the fire regime. Humans have set fires since they first arrived in the region thousands of years ago (Lewis 1973; Bean and Lawton 1973; Aschmann 1977), and deliberate burning is still practiced by ranchers in northern Baja California. According to Meling-Pompa (1991a,b), ranchers have deliberately burned chaparral and meadows to improve browse and livestock access. Sometimes agricultural field burns escape. In the isolated southern Sierra Juárez and northern Sierra San Pedro Mártir, Paipai and Kiliwa Indians make mescal by burning *Agave deserti* and *Yucca schidigera* in roasting pits (Meigs 1935, 1939). Aerial photographs show several burns that spread into adjoining desertscrub and chaparral. Photographs of the Sierra Juárez show many burns established along roads, trails, meadows, and canyons.

Still, the effects of human ignitions on the fire regime is limited because (1) lightning is a significant source of wildland fires (Minnich et al. 1993); and (2) the fire regime in most ecosystems shows evidence of system or self-regulation in which the rate of burning is independent of ignition rates (Minnich and Chou 1997; Minnich et al. in press).

Lightning detection data for the Sierra Juárez reveals that cloud-to-ground discharges average 1.5 strikes per 1,000 hectares per year, or about 25 times the number of fires mapped for the period 1920-1971 (Minnich et al. 1993). As a consequence, only 2-4 percent of cloud-to-ground lightning strikes lead to fires. This percentage is similar to that in southern California and appears sufficient to establish the complex patch structure seen now in northern Baja California (Minnich et al. 1993). The 25:1 ratio of lightning discharges to burns shows



Plate 44. Spring cattle drive through desertscrub on the way to summer pasture in the Sierra San Pedro Mártir.



Plate 45. Forest fire near La Puerta in the Sierra San Pedro Mártir (1987).

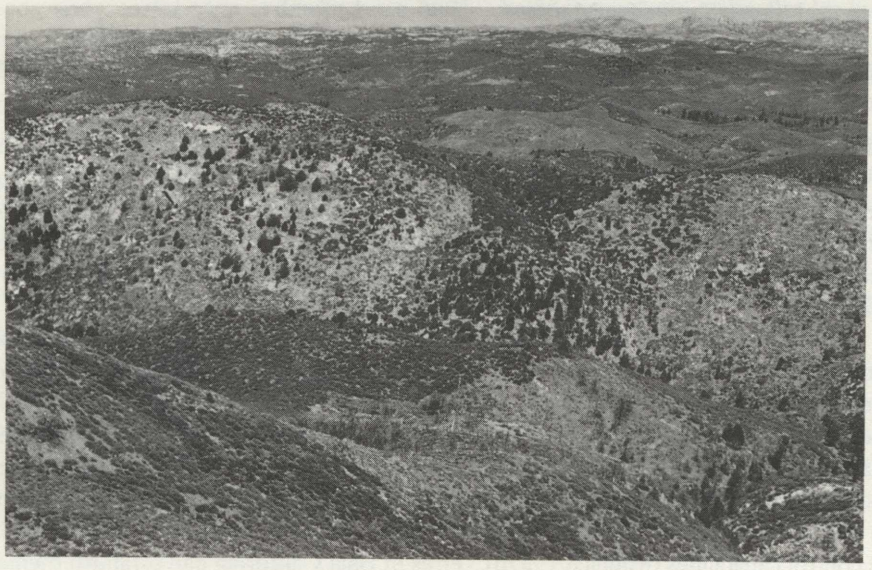


Plate 46. Chaparral fire mosaic in the southern Sierra San Pedro Mártir.

Table 16. Durations of selected fires (1956-1989) in northern Baja California

Fire/region	Year	Duration	Personal Communication
Sierra Juárez			
NW of El Rayo	1982	1 month	V. Preciado
S of Laguna Hanson	1985	1 month	V. Preciado
ESE of San Juan de Dios	1985	1 month	V. Preciado
Sierra San Pedro Mártir			
Picacho del Diablo/eastern escarpment	1956	6 weeks	Werner, 1957
San Ramón	1966	2 months	R. J. Vogl
La Zanja	1974	1 month	F. Mayoral, interview
San Pablo	1985	1 month	F. Mayoral, interview, G. Gastil
La Puerta	1987	17 days	F. Mayoral, interview
Santa Rosa	1987	3 weeks	F. Mayoral, interview
northern Sierra San Pedro Mártir	1989	June-Aug.	F. Mayoral, interview
southern Sierra San Pedro Mártir	1989	June-Aug.	F. Mayoral, interview
central Sierra San Pedro Mártir	1996	1 month	

that most discharges will strike vegetation having insufficient fuels to carry fire. In mixed-conifer forests of the Sierra San Pedro Mártir, spot fires set by lightning occur at frequencies of nearly 1 event per hectare of forest over a fire cycle of 50 years. The fires are randomly distributed, with most occurring in remote locations distant from access. Larger burns accounting for 90 percent of total burn area also originated at remote localities (Minnich et al. in press).

The low percentage of lightning ignitions leading to fires in California is interpreted as evidence of the ineffectiveness of natural discharges (Dodge 1975; Keeley and Zedler 1978; Keeley 1982; Lewis 1973; Vankat and Major 1978; Timbrook, Johnson and Earle 1982; Keeley et al. 1989; Christensen 1993); lightning ignitions, however, seldom immediately establish themselves into burns because of the high humidity normally responsible for the associated convection, and they are more effectively extinguished by suppression forces than are anthropogenic ignitions, which may occur under the most hazardous weather and beyond fire control capabilities (Minnich 1987b). Fires in Baja California can establish themselves as "sleepers," which smolder in large fuels (logs, standing trees) for days or weeks before expanding into burns. This behavior is consistent with observations, by park rangers and scientists, of mountain fires alternately smoldering and spreading for months until extinguished by autumn rains (Table 16). Similar fire behavior was reported in southern

California before fire control was practiced in the late nineteenth century (Minnich 1987b, 1988).

Fire regimes in the woody ecosystems of northern Baja California, such as chaparral, pinyon forest, and mixed-conifer forest, show evidence of being time-dependent and self-regulating (Loucks 1970; Heinselman 1981a,b; Forman and Godron 1986; Riggin et al. 1988; Minnich 1983, Minnich and Chou 1997; Minnich et al., in press)—the rate at which vegetation burns is controlled more by successional processes and fuel buildup than by exogenous factors including ignition rates. As a consequence, the spatial extent of burns is continually shaped by previous the fire history and differential fuel buildup in the patch structure. The small size of burns in Baja California is likely caused by high rates of fire disturbances in ecosystems that resist fire for decades. Because the removal of fuels from previous fires influences the spread of subsequent fires, high fire densities result in the fragmentation of stands into a fine mixture of age classes, precluding large fires (Minnich 1983, Minnich and Chou 1997; Minnich et al., in press; Plate 46). Because these communities become flammable each summer, the interannual spatial extent of burning does not correlate with precipitation (Minnich and Chou 1997). There is little evidence of directional vegetation change from fire that is caused by new patterns of recruitment and successional sequences, as opposed to the more gradual responses occurring in the absence of broad-scale disturbance (Davis and Botkin 1985; Overpeck, Rind, and Goldberg 1990).

Anthropogenic burning may be significant in accelerating the rate of burning in exotic grasslands and coastal sage scrub because flashy, herbaceous fuels make the landscape uniformly flammable regardless of its previous fire history. Increasing fire frequencies due to deliberate burning may accelerate the spatial extent of burning at a regional scale, as has been found in tropical savannas of Africa and South America (Forman and Godron 1986). In Baja California the large fires in the northern valleys correlate with the years of heavy rainfall which promote unusually high growth of herbaceous cover; burning is meager during drought (Minnich 1983); however, grazing may have contributed to this trend by reducing the buildup of fine fuels and the incidence of fire, as in Arizona (Leopold 1924; Martin 1983; Bahre 1991). The limited spatial extent of fire during drought in ungrazed grassland and coastal sage scrub of Alta California suggests that herbaceous biomass may have been too limited to carry fire.

6

THE STABILITY OF ECOSYSTEMS

In summarizing the broad vegetation distributions of northern Baja California in the eighteenth century, we ask two questions about individual ecosystems since that time: (1) How have they maintained stable distributions? and (2) How have they diverged from similar vegetation in California, which has a different land-use history? In the following responses, we consider the specific distributions described by Spanish explorers, the role of disturbance, and the life-history attributes of the dominant species.

DESERTSCRUB

The eighteenth century journals of the Spanish explorers provide a surprisingly modern picture of desertscrub. In describing the Central Desert between San Fernando Velicatá and the southern end of the Sierra San Pedro Mártir at El Salto, the diaries of Link and Crespi singled out the notable arboreal species, *Fouquieria columnaris* and *Pachycereus pringlei*, as well as other modern dominants, including *Agave deserti*, *Simmondsia chinensis*, *Cercidium floridum*, and several cylindropuntia. The Sonoran Desert east of the Peninsular Ranges was covered by *Larrea tridentata* and microphyllous woodlands of *Cercidium floridum*, *Olneya tesota*, and *Fouquieria splendens*. *Prosopis glandulosa* was seen along streams and springs on the eastern escarpment of the Peninsular Ranges. Arrillaga suggested that the perennial cover was dense and more diverse near the Sierra San Pedro Mártir than along the Gulf of California coast at San Felipe, as seen today. "Pasture" was infrequent and was restricted to watercourses, and a few plains that had apparently been doused by recent showers. Some pastures were apparently fields of spring wildflowers, such as those described by Orcutt a century later. *Populus fremontii* and willows were encountered along some arroyos, and palm oases were described in the southern Sierra San Pedro Mártir and along the eastern escarpment of the Sierra Juárez.

The distributions of a few frequently described species in the Spanish diaries appear to be the same as now along the routes of these expeditions (cf. Hastings, Turner, and Warren et al. 1995). Crespi stated that the Franciscan expedition "left the cirio behind" in the vicinity of Valle La Gringa, the present northern limit of the species along his route, and Linck stated that the cardón (*Pachycereus pringlei*) extended as far north as the Sierra San Pedro Mártir. In the Sonoran Desert, Arrillaga in 1796 and Nelson (1921) a century later saw a northern outpost of *Bursera hindsiana* near San Felipe. The current limit of this species along

Nelson's and Arrillaga's routes is in the same area, 10 kilometers northwest of San Felipe. Linck saw palm oases on the eastern escarpment of southern Sierra San Pedro Mártir, most likely *Brahea armata*, as far north as its present limit at Cañon El Cajón. Crespi described palms on the west slope of the range as far north as Arroyo San Pablo, also the present limit. Arrillaga described the palm oases along most of the eastern escarpment of the Sierra Juárez. Crespi, Serra, and Linck each record the shift between desertscrub of the central peninsula and mediterranean scrub in the Sierra San Pedro Mártir by noting the appearance of *Juniperus californica* near its southern limit near El Salto. Except for agricultural clearing in Valle Mexicali, the desertscrub of northern Baja California appears to have been little affected by human disturbance. There were no mining strikes in this community (Chaput, Mason, and Loperena 1992), and the impact of livestock appears to have been minimal.

Rather, it is recurrent fluvial disturbance that is critical to the life history and biogeography of many desert ecosystems. Flash floods occur periodically along arroyos and alluvial fans of the Sonoran and Central Deserts as the result of summer cloudbursts and Mexican west coast tropical storms (Smith 1986). *Olneya tesota*, *Cercidium floridum*, *Prosopis glandulosa*, and *Dalea spinosa* possess hard seeds whose germination is enhanced by scarification associated with sediment transport during high runoff (Zedler 1981). Leguminous microphyllous woodland species also extend deep taproots and follow the flash-flood moisture front through the soil to the water table, which provides secure long-term moisture (Rundel et al. 1982; Nilson et al. 1983). These species seldom establish at other times, including after fires because soils are seldom wetted to depth by natural rainfall.

Perhaps most striking is how well the Spanish accounts of *Washingtonia filifera* and *Brahea armata* oases match modern distributions, especially in view of the fact that the palms are found primarily along watercourses and have experienced many flash floods during the past 200 years. The native palms are well adapted to periodic flooding of their natural habitats at permanent wet sites. An inventory of palm oases surrounding the Coachella Valley conducted after tropical storm Kathleen (6 to 10 centimeters of precipitation on September 9-10, 1976) showed that postflood recruitment was much greater in populations subject to flash floods than in those experiencing no fluvial disturbance (Cornett 1985). These shallow-rooted palms, however, are easily uprooted by intense flash floods and are generally absent from canyons subject to high runoff. On the eastern escarpment of the southern Sierra San Pedro Mártir, numerous populations of *Brahea armata* grow in small drainages having less erosive power. Most such drainages contain springs that seep from volcanic cap rock overlying granitic basement. The gap in palm oases north of Cañon El Cajón—in contrast with the remainder of the Peninsular Range escarpment—may be related to intense cycles of flash flooding due to this region's higher altitude and heavier orographic and convective rainfall.

The most significant change in scrub of northern Baja California has been the recent invasion of exotics, in particular the spread of herbaceous exotics such as *Bromus rubens*, *Schismus barbatus*, and the new Saharan Desert mustard *Brassica tournefortii*. These exotics have increased the available fuel and fuel continuity and rates of burning in the Sonoran and Mojave Deserts of Arizona and California (Beatley 1966; Rogers and Steele 1980; McLaughlin and Bowers 1982; Brown and Minnich 1986; Rogers and Vint 1987) and

will eventually threaten to accelerate the pace of burning in northern Baja California. Until the arrival of exotics it appeared that the only community in the Colorado Desert in which fire was a significant abiotic factor was the palm oases (Burk 1988). Both palm species, *Washingtonia filifera* and *Brahea armata*, establish new canopy from preexisting meristems (Vogl and McHargue 1966). The palms are more fire tolerant than understory species. Fire opens understory, promotes seedling establishment, and enhances the subsurface water supply, reducing competition for water.

In northern Baja California, fires that cross onto the eastern escarpment of the Peninsular Ranges cease spreading in the ecotone between pinyon forest and creosote bush scrub/ microphyllous woodlands (Minnich 1983, Minnich and Chou 1997; Minnich et al., in press). The future impact of fire in the deserts of northern Baja California, however, will very likely be similar to that reported for California and Arizona. In California, extensive outbreaks of burning took place in the Mojave Desert during the wet years of 1978-1985 (Brown and Minnich 1986). After a hiatus during a drought from 1986 to 1990, fires are again breaking out after record-breaking rains in 1993 (Minnich 1994a,b). Studies in these regions have shown that some members of desertscrub have a low tolerance to burning, and adaptations to fire in this type of vegetation have not strongly developed (Rogers and Steele 1980; O'Leary and Minnich 1981; McLaughlin and Bowers 1982; Rogers 1986; Brown and Minnich 1986). Many dominants neither sprout nor produce seedlings rapidly after disturbances. Alien species, by annually forming cured groundcover, may cause short fire intervals that breach desertscrub successions before long-lived species achieve dominance, producing rapid changes in shrub species composition. Fires often cause local extirpation of long-lived species (*Larrea tridentata*, *Ambrosia dumosa*, and *Opuntia* spp.) and encourage the colonization of short-lived, poorly competitive species with high reproductive capacities (*Hymenoclea salsola*, *Encelia farinosa*, *Salazaria mexicana*, *Viguiera deltoidea*, *Eriogonum fasciculatum*, *Gutierrezia microcephala*, and *Acamptopappus sphaerocephalus*). These pioneers typically grow along washes, sandy sites, and steep slopes subject to recurrent fluvial and aeolian disturbances (Vasek 1979-80, 1980). For example, a single burn on the eastern escarpment of the San Jacinto Mountains near Palm Springs, in creosote bush scrub dominated by *L. tridentata*, *A. dumosa*, *O. acanthocarpa*, and *O. echinocarpa*, initiated a successional sequence dominated by *Encelia farinosa*, a resilient shrub found in fire-prone Californian coastal sage scrub (Brown and Minnich 1986).

The impact of rare fires on the microphyllous woodland trees *Olneya tesota*, *Cercidium floridum*, *Prosopis juliflora*, and *Dalea spinosa* may be less significant because of the strong resprouting habit of these species. Such behavior may be a generalized adaptation to flash-flood disturbances in their habitat along washes and alluvial fans (Tratz 1978; Zedler 1981).

Northern Baja California has yet to face this new fire threat, but it may only be a matter of time, because Old World exotic herbs and grasses are already widespread in the region.

PINYON FOREST

Pinyon forests along the crestal plateaus of the Sierra Juárez are now occupied by a few cattle ranches, whereas stands on the eastern escarpment of the Sierra San Pedro Mártir have never

been settled. The major use of this ecosystem by the native Americans was the autumn harvest of pinyon nuts. As late as the mid-twentieth century, the surviving Paipai and Kiliwa tribes still gathered pinyon nuts in the mountains near Paso San Matías (Meigs 1935, 1939).

Infrequent descriptions of pinyon forest in eighteenth-century Spanish diaries are consistent with modern distributions. Linck saw pinyons in the southern Sierra San Pedro Mártir, and Crespi and Serra encountered them on the west base of the Sierra San Pedro Mártir. Arrillaga made note of them in the plains between El Alamo and Santa Catarina and in the regions along the crest and eastern margin of the Sierra Juárez.

The fire regime of pinyon forests, as mapped from aerial photographs, has been one of long-period stand-replacement fires at intervals lasting from 125 years to longer than 250 years (Minnich and Chou 1997; Minnich et al. in press), similar to those in California (Wangler and Minnich 1997) and the Southwest (Erdman 1970; Koniak 1985). At these rates, most forests have probably burned at least once since the Dominican mission period. Long fire intervals are due to the low productivity of this semiarid ecosystem. Fragmented *Pinus quadrifolia* forests on the Pacific slope probably burn at the same rate as chamise chaparral within which it grows, at 50- to 70-year intervals. Short fire recurrences are precluded by the scarcity of fine fuels in this ecosystem.

There are no formal studies of postfire succession in these ecosystems in northern Baja California. In southern California and the Southwest, denuded forests are often followed by a shrub phase dominated by species established by long-range seed dispersal (e.g., *Artemisia tridentata* and *Chrysothamnus* spp.), resprouting (e.g., *Purshia tridentata* and *Quercus turbinella*), and scarification of seed in the soil (e.g., *Ceanothus greggii* and *Fremontodendron californicum*). Although the seeds of pinyon pines are continually cached by birds, especially jays and nutcrackers (Van der Wall and Balda 1977), the initial establishment of *Pinus monophylla* appears to be delayed 20 to 30 years after fire. The delay is apparently caused by soil heaving that is associated with diurnal freeze and thaw processes that last until there is an establishment of a well-developed shrub layer (Wangler and Minnich 1997). Pinyon forests mature in about 100 years, and their growth is accompanied by a decline of the early successional shrub layer (Wright and Bailey 1982; Wangler and Minnich 1997).

The fire ecology of *Pinus quadrifolia* has not been investigated. In cursory observations, we find that this pinyon recruits quickly after burns and forms mature forests within 50 years. Such resilience is consistent with the shorter fire intervals of chaparral. There is no evidence that the seed survives fires through cone serotiny; hence, it appears that the rapid establishment of saplings arises from efficient caching of seed from living stands by birds and mammals. In the Sierra San Pedro Mártir, *P. quadrifolia* forest distributions have changed rapidly since aerial photographs were first taken in 1956. New colonies are continuously forming in old growth patches of chaparral, while old stands are denuded by canopy fires. Some populations persist longer on dry south-facing slopes and on the upper eastern escarpment, where fire intervals are longer.

Deliberate burning would appear to have little impact on the fire regime of pinyon forest in the northern peninsula because lightning discharge rates vary from 2.0 to 3.2 per 1,000 hectare per year (Minnich et al. 1993), and fire intervals are a century or longer. In a median

burn size of 1,000 hectares, most forests would experience 100 lightning strikes between fires.

Land uses doubtless had local impact on this ecosystem. *Pinus quadrifolia* and *Juniperus californica* were utilized for construction and as fuel in smelting kilns in late-nineteenth-century gold strikes at Japá, Tres Pozos, and El Alamo (Chaput, Mason, and Loperena 1992). The demand for fuelwood and timber for domestic heating and construction at the mining camps may have had an impact on local vegetation, but was probably of little significance compared with the major strikes in Nevada, Arizona, and New Mexico, where woodcutters eradicated large areas of pinyon juniper because no pinyons and few junipers could tolerate the pollarding techniques (Lanner 1977; Young and Budy 1979; Samuels and Betancourt 1982; Bahre 1991). At Japá, which briefly grew to 500 inhabitants during the 1870s, miners built log houses from abundant "pine and cedar" (Chaput, Mason, and Loperena 1992). Presently, *Pinus jeffreyi* occurs locally in the basins to the south (Minnich 1987a). *Calocedrus decurrens* [= juniper?] is restricted to the central Sierra Juárez, 50 kilometers away, and it is doubtful that this species was utilized for construction (perhaps the log houses were built from pinyon and *Juniperus californica*). Pinyon forests are common at Japá, and the effects of mining are hard to determine because the boundaries are presently more shaped by recent burns than by earlier mining operations. At El Alamo, the Biological Survey reported that pinyon [*Pinus quadrifolia*] and juniper [*Juniperus californica*] were cut out for a radius of 10 to 15 kilometers around the mine (Nelson 1921). The ores, however, were already exhausted by the time of this expedition (1906), and both tree species are presently common there. The local distribution of pinyon there was apparently the same then as now. The *Lower Californian* (June 5, 1890) reported that "two small peaks to the north of the mine," called "Piñones," were covered with a "fringe of Piñon pines." Panoramic photographs a few miles from El Alamo about 1900 from the Zárate family archives reveal that this mine had little impact on the chaparral and *J. californica*.

We have observed fuelwood being harvested locally in the Sierra San Pedro Mártir for use at San Felipe; however, the low demand for wood and the increased use of fossil fuels seems to be limiting the exploitation of these trees. Gathering of fuelwood at distances greater than 15 kilometers from towns is regarded as unprofitable. For most rural areas of Baja California, fossil fuels are the only option (Anonymous 1988). Most pinyon forests grow in the largely inaccessible eastern escarpments of the peninsular ranges.

Cattle ranchers have utilized *Juniperus californica*, *Adenostoma sparsifolium*, *Pinus jeffreyi*, and other species for fenceposts and corral construction since the early nineteenth century, but the impact from the construction and maintenance of such infrastructure is unknown. Wood utilization may have been light because most of the mountains have remained open range until recently, when rangelands began to be fenced in the Sierra Juárez north of Nejí and in the coastal ranges north of Ensenada. The Sierra San Pedro Mártir remains today entirely open range (Meling Pompa 1991a,b). Most fencing was built to subdivide prime meadows and ranchsteads. *Pinus jeffreyi* has also been used for construction of primitive summer shelters.

MIXED CONIFER FOREST

The Californian mixed-conifer forests covering the Sierra Juárez and the Sierra San Pedro Mártir are found nowhere else in Mexico (Wiggins 1960, 1980; Rzedowski 1978; Minnich 1987a). They are also unique within the Californian floristic province in that the forests, open and parklike, are maintained by periodic ground fires without human interference (Minnich et al. in press). These forests have experienced neither wide-scale logging nor land clearing, and grazing appears to have had little impact except in the meadows.

Fragmentary written accounts by the Spaniards suggest that past distributions were similar to those today. Longinos-Martínez and Arrillaga described the extensive pine forests of the Sierra San Pedro Mártir and Sierra Juárez. Although *Pinus jeffreyi* is dominant in the region, Longinos-Martínez also referred to "trees of different species" when he traveled through mixed conifer-forests covered with *Abies concolor*, *Calocedrus decurrens*, and *Pinus lambertiana* in the highest parts of the Sierra San Pedro Mártir.

The diaries realistically capture the local pattern of forests. Linck and Velasquez wrote that forests on the eastern escarpment of the Sierra San Pedro Mártir were restricted to the highest catchments. In words that would equally well describe the same vegetation there today, Longinos-Martinez described pine forest along a cattle trail on the west slope of the range between Valladares and La Grulla. Longinos-Martinez also stated pine forests fringed the meadows. In the Sierra Juárez, Arrillaga's journal captured the increasing size of pine forests from Santa Catarina northward to Laguna Hanson. Most noteworthy is his remarkably current depiction of the interdigitation of pine forest in the basins and chaparral-covered ridges and mesas along Arroyo El Barbón in the Sierra Juárez.

Fire plays a vital role in the dynamics and structure of Californian mixed-conifer forest (Kilgore 1981; Wright and Bailey 1982; Rundel, Gordon, and Parsons 1988; Swetnam 1993; Barbour and Minnich 1998). Studies in the Sierra San Pedro Mártir have shown that mixed-conifer forests survive ground fires as a consequence of their tall stature and thick bark, which protects the cambium from heat scorch (Minnich et al. in press). Surface fires, which occur every 50 years, produce an open forest structure caused by selective elimination of sapling and polesize trees in the understory, yielding mixed stands of old-growth and medium-age forests with scattered saplings. Photographs of Vallecitos by Ford Carpenter in 1903 show evidences of ground fires (Plate 19). The boles of many trees exhibit hollowed cavities near the ground. Others have blackened bark from a recent burn, apparently one recorded by fire scar dendrochronologies in 1899 (Burk 1991). Fire scar chronologies at several locations at Vallecitos also record another major record burns in 1860, and aerial photographs show an extensive burn there in 1946. Burns greater than 500 ha occur nearly every year in the Sierra San Pedro Mártir. In addition to major burns, there are numerous local spot burns initiated by lightning, but these comprise light fires having little nor cumulative impact on the forest dynamics, other than to consume small patches of needle litter.

Most forests have a rather flat, multiple-age structure, but some have a classic climax-type, reverse J-shaped distribution, the majority of stems having diameters between 70 and 100 centimeters. Stand densities range from 50 trees per hectare in *P. jeffreyi* forest to 150 trees per hectare in *A. concolor* forest. Surface fires are relatively intense, because fuel

buildup between fires results in flame lengths that are sufficient to kill saplings, the majority of polesize trees, and a few canopy trees in most stands. Stand-replacement fires, however, are localized to forests that are both located on steep, exposed high peaks and ridges, and that have a dense understory of timberland chaparral and *Quercus chrysolepis*.

Mixed-conifer tree species respond differently to fire frequency and intensity (Barbour and Minnich 1998; Rundel, Gordon and Parsons 1988). The dominance of *P. jeffreyi* in mixed-conifer forests at the highest elevations of the Sierra San Pedro Mártir may be related to fire intensities that favor survival of this pine. *Pinus jeffreyi* bark is thicker and its canopy is higher above ground fuels than those of *Abies concolor* and *Calocedrus decurrens*. Moreover, the regeneration of *P. jeffreyi* is stimulated by ground fires that are intense enough to burn away the litter and shrubs, whereas ground fires inhibit regeneration of *Abies concolor* and *Calocedrus decurrens*, which have thinner bark and low canopies exposed to flames. Monotypic forests at lower altitudes grow in areas too dry for the establishment of any tree except *P. jeffreyi* (Minnich 1987a).

The open forests of the Sierra San Pedro Mártir have been attributed to the dry climate of the region rather than to a lack of fire disturbances (Nelson 1921; Oberbauer 1996); however, stand densities are similar to the presuppression densities in the forests of Alta California (Minnich et al. 1995; Barbour and Minnich, 1998; Minnich et al., in press). Mean annual precipitation in the Sierra San Pedro Mártir averages 60 to 70 centimeters, similar to that in the mountains of southern California, and the southern and eastern portions of the Sierra Nevada, where stand-thickening is presently taking place under fire suppression (Minnich et al, 1995; SNEP, 1997; Barbour and Minnich, 1998).

There is evidence that stands in the Sierra San Pedro Mártir would experience stand-thickening if fire were excluded, similar to forests in California (Minnich et al in press). Sapling densities are 2-4 times that of overstory trees (100-600 ha^{-1}), and succession chronosequences reveal an increase of 15 polesize stems ha^{-1} after 50 yr^{-1}. Local forests that have not burned for > 70 years support tree densities as high as 400 stems ha^{-1}, similar to forests in California (Vankat, 1977; Vankat and Major, 1978, Minnich et al, 1995). Stand-thickening is not evident at the landscape scale, even with 50 year fire intervals, because the growth of new stems is countered by high fire mortality rates. Apparently, the rate of entry into the overstory class is balanced by mortality rates in the overstory class.

Present forest densities may reflect a long-term stable forest population structure, despite widespread fire during the twentieth century. Colonel Allen's estimates of stem densities, stem diameters, and species composition in 1888 are remarkably similar to our samples of present stands (Table 8). Fire-scar chronologies show no significant change in fire recurrence intervals since 1800 (Burk 1991). In addition, fire chronosequences show no statistical change over time in the density of mature overstory trees, which indicates climaxlike, steady-state dynamics.

CLOSED-CONE CONIFER FOREST

The closed-cone conifer forests of northern Baja California (*Pinus attenuata*, *P. muricata*, *Cupressus guadalupensis* ssp. *forbesii*, *C. arizonica* var. *stephensonii*) were not described

in the late eighteenth century, perhaps because these communities were as widely scattered as they are today. Indeed, several populations of *Pinus coulteri* and *P. attenuata* have only been recently discovered (Minnich 1987a). The only definitive reference to this vegetation in the Spanish diaries is Arrillaga's description of the *Pinus coulteri* forest on Sierra Blanca near Valle Guadalupe. Arrillaga's record of this stand appears to be a significant observation of an isolated population. This is the only report of any pine forest along his third journey between the high plateaus of the Sierra Juárez and the Pacific coast north of Ensenada. Today, tall pine forests do not exist within a 50-kilometer radial distance of this stand.

The occurrence of closed-cone conifer forests in dense brush makes them subject to stand-replacement fires (Vale 1979; Borchart 1985; Vogl et al. 1988), but there is little evidence that fire has adverse effects on this ecosystem in Baja California. Aerial photographs show that *Cupressus guadalupensis* ssp. *forbesii* and *Pinus attenuata* form even-aged stands in varying degrees of co-maturity with chaparral patch structure, indicating that both species have fared well with regard to the chaparral canopy fire regimes during the present century. Changes in the distribution as a consequence of deliberate burning are unlikely because chaparral fire intervals are not significantly influenced by ignition rates (Minnich and Chou 1997).

Studies in Alta California have shown that closed-cone conifers respond to recurrent intense fires through cone serotiny, high reproductive effort, and colonizing ability (Vogl et al. 1988). Seedlings germinate from seed retained in closed cones that are persistent at the ends of branches or along the boles of fire-killed parent trees. These disperse after the burn. *Pinus attenuata* cones are truly serotinous; seed is not released except through fire (Vogl 1973). *P. coulteri* cones require two years to mature and may open as late as January or February and thus may be closed sufficiently to protect the seed from summer and autumn fires. Seedlings avoid drought through rapid early photosynthesis and rapid penetration of roots into the soil (Wright 1966, 1968). During later succession, *P. coulteri* and *P. attenuata* saplings grow rapidly through the shrub canopy, becoming polesize within 20 to 45 years. Cones are produced within 10 to 20 years. *Cupressus arizonica* var. *stephensonii* growing on chaparral-covered mesas in the southern Sierra Juárez of northern Baja California occurs as short-lived, even-aged stands because of brushfires. However, the species also occurs as long-lived trees along nearby arroyos protected from burning (Moran 1977).

The strategy of obligate seeding in closed-cone conifers could make them vulnerable to rapid vegetation changes from fire. Because seed is very locally dispersed, establishment by long-range dispersal from living distant stands is unlikely. Indeed, a single failure in seedling establishment—owing to drought or seed destruction—may cause local extinctions. Such failures could possibly explain their fragmented distributions; for example, a *Cupressus forbesii* population in San Diego County was eliminated by intense fire (Zedler 1981). Several workers have concluded that *P. coulteri* is being replaced by chaparral (Wright 1968; Wilson and Vogl 1965; Vale 1979; Tally and Griffin 1980; Griffin 1982). In Baja California, isolated *P. coulteri* populations mostly occur on bedrock-dominated hillsides where it normally survives burns. These fire-resistant sites may provide a secure seed source that may become critical when fires are followed by droughts that are severe enough to cause recruitment failure (Minnich 1986b). Closed-cone forests do not appear to be restricted to

nutrient deficient substrates, as with many stands in Alta California (Vogl et al. 1988). *Pinus coulteri*, *P. attenuata*, and *Cupressus forbesii* are found on granites, the Alisitos formation, and volcanics, although *P. muricata* is restricted to Eocene sediments along the coast.

COAST LIVE OAK WOODLAND AND RIPARIAN FORESTS

Coast live oak woodland (*Quercus agrifolia*) and riparian forests (*Populus fremontii and Platanus racemosa*) were the only tall forests in the coastal lowlands and foothills of northern Baja California in the eighteenth century, as indicated by Crespi's letter to Palou (Bolton 1927), with their distribution restricted to moist or wetland habitats along watercourses and basin floors. The Spanish diarists provided comprehensive descriptions of the distribution of these ecosystems because they indicated the presence of water (cf. Minnich 1987a). *Populus fremontii* was recorded to be present along canyons on the western and eastern escarpments of the Sierra San Pedro Mártir and along most coastal watercourses from San Rafael to the international boundary. *Platanus racemosa* was described only in drainages near the Pacific coast, especially in the near-coast ranges. *Q. agrifolia* was observed on the western base of the Sierra San Pedro Mártir and in the near-coast ranges from La Grulla to Cañon San Carlos, Cañon Arce, Valle Guadalupe, and Boquilla de Santa Rosa. Arrillaga also described riparian forests and *Quercus agrifolia* in the near-coast ranges (Arroyo San Isidoro, Arroyo la Grulla, Valle Guadalupe), as well as in Valle Ojos Negros and along tributaries of Cañon El Barbón in the Sierra Juárez. He also saw this oak in the transverse ranges at Los Encinos and at San Pablo. The southern limits of these trees were similar to those presently. The southernmost grove of *P. fremontii* in northern Baja California was noted independently at El Salto by Linck, Crespi, and Serra. The Franciscan missionaries first encountered *Q. agrifolia* at its present southern limit along Arroyo San Antonio at the west base of the Sierra San Pedro Mártir.

Coast live oak and riparian forests are well adapted to natural disturbance, and it is doubtful that fire alone could produce substantial changes in their distribution. Tree canopies are often unburned or scorched because of their stature. Denuded *Quercus agrifolia* resprout vigorously after burns and develop a full canopy in a few years (Plumb 1980). Riparian trees are also strong resprouters. Coastal hardwood forests are also subject to periodic flooding, especially along the primary canyons leading out of the Peninsular Ranges. Fluvial channel-scouring periodically denudes riparian vegetation; however, most stream trees and shrubs, including cottonwood (*P. fremontii*), sycamore (*P. racemosa*), willows, and *Baccharis* spp., are capable of rapid, long-range seed dispersal, having either plumbed or winged seeds, immediate establishment in low fertility soils, and rapid succession to maturity (Sauer 1988:53).

These forests have been exploited for timber and cordwood since the Mission Period, but the extent to which they have been altered during the past two centuries is unknown. The crooked boles of these trees make poor timber. Indeed, the missionaries preferred to exploit pine forests much farther away in the Sierra Juárez. Wood was used for fuel, construction, and, especially, kilning bricks. Because the trees can withstand pollarding or stumping because of their sprouting habit, the removal of stands would require repeated and intensive

utilization of these species. Aerial photographs taken since 1938 reveal no wide-scale removal of these forests; however, *Quercus engelmannii* may have been extirpated from the Sierra Juárez along the international boundary, especially where the demand for fuelwood was intense near Tecate. Although numerous small colonies exist within 1 kilometer of the U.S. side of the boundary, only one stand exists in México, 4 kilometers south of Tecate (Minnich 1987a). *Q. engelmannii* is a poor sprouter after disturbance, which is typical of deciduous oaks, and would fare poorly from pollarding. It is questionable, whether *Q. engelmannii* was ever plentiful on the Mexican side. The tree is abundant in San Diego County on Mt. Palomar and on the west slope of the Laguna Mountains, but it becomes ever more infrequent toward the international boundary (Griffin and Critchfield 1976).

Livestock browsing seems to have influenced recruitment and stand structure in *Q. agrifolia* woodlands, in particular in stands surrounding productive meadows with higher carrying-capacity than chaparral (Table 14). In California, grazing appears to maintain open, old-growth stands because this oak recruits poorly even under slight grazing pressure (Griffin 1971, 1976). The present stand structure of *Q. agrifolia* woodlands in northern Baja California appears to reflect grazing intensities. In the Sierra Juárez between Tecate and Neji and in the coastal ranges north of Ensenada, for example, *Q. agrifolia* woodlands comprise open parks of old-growth trees, especially near meadows where livestock are grazed. In contrast, the remote stands on the western flanks of the Sierra Juárez (e.g., Arroyo El Barbón) and the Sierra San Pedro Mártir consist of dense, mixed-aged stands.

It is doubtful that fire has produced substantial changes in the distributions of *Q. agrifolia* woodlands and riparian forests. The similarity of fire intervals under divergent land-management systems in southern California and northern Baja California suggests that fire return intervals have been steady over the past centuries. Tree canopies are often unburned or scorched because of their stature. Denuded trees resprout vigorously after burns and develop full canopies in a few years (Plumb 1980).

COASTAL SAGE SCRUB/MARITIME DESERTSCRUB

The Spanish explorers never coined a term for coastal sage scrub or for maritime desertscrub. As a result, the past distribution of these ecosystems can be inferred from the list of dominant species in the journals. The localities given for these species are consistent with modern distributions. The Franciscan expeditions described dense stands of *Agave shawii*, *Simmondsia chinensis*, and cylindropuntias (maritime desertscrub) from El Carricito to Valle San Telmo and from Valle San Rafael to El Salado. The latter site is near the northern limit of conspicuous succulence in this community (Mooney 1988). Crespi recorded the presence of *A. shawii* between San Fernando Velicatá and Cieneguilla but realized in retrospect that this leaf-succulent was missing from the foothills of the Sierra San Pedro Mártir between La Cieneguilla and Valladares. It was absent from the floor of Valle San Telmo. *Agave shawii* was also reported in association with *Opuntia littoralis* along the coast north of Valle Guadalupe. He definitively stated that "the mescales end" in the vicinity of El Rosarito, the present northern limit of the species. *Opuntia littoralis* was noted along its modern range from near Valle Guadalupe north to the international boundary. Crespi and Serra recorded

the occurrence of *Simmondsia chinensis* almost daily in their journeys between San Fernando Velicatá and El Salado but did not record it to the north. Except for a few populations along coastal bluffs at Punta Ensenada (Wiggins 1980; Hastings, Turner, and Warren 1972), El Salado is the present northern limit of this species along the Franciscan route.

Longinos-Martínez recorded the presence of *Salvia* during his trek along Cañon Santo Domingo into the Sierra San Pedro Mártir. His reference to "rosemary" may refer to another fasciculate- or linear-leafed shrub of coastal sage scrub, such as *Eriogonum fasciculatum* or *Keckiella antirrhinoides*, or possibly *Adenostoma fasciculatum*. His reference to *Salvia* is the only taxonomic reference to an aromatic species in any of the diaries. This is surprising in view of the traditional use of herbals in Spain and other countries of the Mediterranean basin. Arrillaga's disinterest in coastal sage scrub has left us with little information on this ecosystem in the areas that he explored. Perhaps his references to the "bare hills" below the chaparral belt were a negative reference to this ecosystem.

Coastal sage scrub and maritime desertscrub in northern Baja California may become profoundly changed due to the invasion of Old World exotic species that compete for resources and shorten fire intervals because of increases in flashy fuels (Westman 1981; O'Leary 1990; D'Antonio and Vitousek 1992). Most taxa have high fire mortality rates from canopy burns but produce abundant seed that disperse widely. Seedlings establish from a preburn seed cache (*Salvia apiana*, *S. mellifera*) or germinate from seed dispersed by wind (*Artemisia californica*, *Encelia farinosa*, *Eriogonum fasciculatum*). Resprouting species flower vigorously during the first postburn years and provide nonrefractory seeds that germinate in subsequent years, leading to mixed-aged stands (Westman 1981). Recruitment and growth to maturity are extremely rapid (ca. 10 to 20 years) for most taxa (Westman 1982).

Studies in California have shown that coastal sage scrub is resilient under periodic fire (O'Leary 1990), but recurrence intervals of less than 5 to 10 years will degrade stands and lead to site domination by nonnative grasses (Wells 1962; Kirkpatric and Hutchinson 1980; Malanson 1984). In northern Baja California, however, the rate of burning (10.2 percent of coastal sage scrub burned during 1972-1980) suggests that the region is not experiencing stand-degrading fire intervals, but burning is frequent in the valleys north of Ensenada where exotic bromes, mustards, and oats are abundant.

The arrival of Old World exotics may have made coastal sage scrub more attractive for livestock. Increases in carrying capacity and livestock may further augment browse pressure and physical removal of canopy. Presently, the coastal and inland basins show the unmistakable the effects of grazing, including contoured livestock trails, thinning of the herbaceous layer, pruned shrubs, and fecal deposits. Browse preferences may result in selective removal of some shrub species (Genin and Badan-Dangon 1991). Disturbances apparently encourage *Eriogonum fasciculatum*, a shrub highly preferred by cattle for fodder. No historical baseline data exist to evaluate the species composition and structure of coastal sage scrub prior to grazing and the arrival of exotic annuals.

CHAPARRAL

Chaparral is renowned for its intense canopy fires and vigorous postfire recovery, and it is doubtful that humans have influenced this resilient ecosystem. Most chaparral in northern Baja California has burned within the past 70 years (Minnich 1983; Minnich and Chou 1997; Minnich et al., in press) and probably burned several times in the past 200 years. Yet, the diaries provide little evidence that the broad-scale distribution of chaparral has changed historically. Link, Serra, Crespi, and Longinos-Martínez described this ecosystem where it is presently widespread: the southern and western flanks of the Sierra San Pedro Mártir, in the mountains northwest of San Vicente, and between Santo Tomás and Ensenada. Arrillaga rode through chaparral in many areas of the Santa Catarina/El Alamo Plain, the Sierra Juárez, on Sierra Blanca near Valle Guadalupe, and at Arroyo La Grulla in southern Ensenada Bay. He also indicated several phases of dominance, including **chamizo** (chamise, *Adenostoma fasciculatum*), **madroño** (*Arctostaphylos* spp.), "big **chamizo**" (*Adenostoma sparsifolium*), and **varejón** (*Fraxinus trifoliolata*). **Madroño** tended to occur at higher elevations whereas **chamizo** was dominant at lower altitudes. Arrillaga also suggested a semiarid phase with succulents (platyopuntias), *Simmondsia chinensis*, **zimmarón** (*Acacia greggii*), and **nopal** (*Opuntia basilaris*) at Santa Catarina, Puertezuelo, and western Valle Trinidad. These species are now found with chaparral in all three areas. Many chaparral genera, including *Ceanothus*, *Rhus*, *Prunus*, and *Rhamnus* were not distinguished by the early Spaniards.

Arrillaga frequently noted that chaparral occupied hillslopes, while intervening basins were filled with grasslands (pasture), oak woodlands, or pine forests. Near Puertezuelo he accurately described the modern transition from Sonoran desertscrub to chaparral "halfway up the slope" (1,000 to 1,200 meters) on the eastern escarpment of the southern Sierra Juárez. He also listed the modern dominants at several localities including Puertezuelo, Cañon el Barbón in the western Sierra Juárez, Santa Catarina, the pass between the plains of Santa Catarina and Valle la Trinidad, and Valle la Trinidad itself. The accounts of the Biological Survey and Orcutt a century later in the southern Sierra San Pedro Mártir, El Alamo, and the west slope of the Sierra Juárez are also consistent with the present vegetation.

Although chaparral has been deliberately burned to improve access and the browse for livestock, the impact of anthropogenic ignitions on the structure and species composition of this ecosystem is probably slight because the community has properties of a time-dependent, fire-resistant ecosystem (Minnich 1983, Minnich and Chou 1997). Fire intervals average 50 to 70 years and are unaffected by the number of fires. Indeed, ranchers who deliberately burned chaparral near El Rayo and La Rumorosa ignited the smallest fires (Minnich and Chou 1997). Intervals in northern Baja California are also similar to those in the chaparral of southern California, where reduced fire densities have led to compensating increases in fire size throughout the region. Before fire control in southern California, a fine-grained patch structure existed in the region, much like the present-day stand structure in northern Baja California (Minnich 1983; 1987b; Minnich and Chou 1997). Lightning detection rates in chaparral average 1.0 to 2.2 strikes per 1,000 hectares per year, and a very low proportion of ignitions leading to fires (2 to 3 percent) would account for the density of fires now occurring in the chaparral of northern Baja California (Minnich et al. 1993).

Chaparral in northern Baja California is stable under variable fire intervals and fire sizes because most shrub species are long-lived and survive by resprouting or by a buildup of seed caches in postfire succession. Obligate long-range seed dispersal into burns is not a trait of any shrub species (Keeley 1989; Minnich and Bahre 1995); for example, chronosequences in chamise chaparral after 1920 along the international boundary east of Tecate show that postfire successions were virtually identical despite the occurrence of large burns on the U.S. side and numerous small ones on the Mexican side (Minnich and Bahre 1995). Research has shown that short-interval fires (less than 5 to 10 years), which are often carried by flashy herbaceous cover, can eliminate non-sprouting species through the destruction of seed caches and the enhanced mortality of sprouting species from carbohydrate depletion (Hanes 1981; Reid and Oechel 1984). In Baja California, fire recurrences this short seldom occur despite the high ignition rates (Minnich and Chou 1997). Moreover, chaparral seems resistant to invasion by flashy exotic grasses and forbs, even after fire or other disturbances (Sauer 1988), apparently because of the characteristically impoverished soils on which it grows. Franco-Vizcaíno et al. (1994) found that chaparral soils at several locations in coastal northern Baja California were deficient in five nutrients and concluded that the adaptation of shrubs to multiple nutrient deficiencies may give chaparral species a competitive advantage against invasion by exotics that have high nutrient requirements (cf. Huenneke 1989).

Using the accounts of the Portolá (1769) and Anza expeditions (1771-1776), several researchers concluded that fire suppression led to the displacement of grasslands by chaparral in California. The lengthening of fire intervals was deduced from the assumption that increases in ignition rates cause shorter fire intervals (Bonnickson 1980, 1981; Keeley et al. 1989). The invasion of former grasslands by chaparral in former Chumash territory near Santa Barbara has been attributed to the cessation of deliberate burning with the demise of the Indians. The expansion of chaparral was based on reports of fire by Crespi and on observations of grassland at Gaviota Canyon that is now covered by chaparral (Timbrook, Johnson, and Earle 1982). Similarly, Dodge (1975) cited Crespi's descriptions of hillslopes dotted with small oaks, small trees, and rosemary as evidence of open woodlands with an understory of grasslands. From these descriptions, he postulated an extensive invasion of grasslands by chaparral in San Diego County as a result of fire suppression and grazing during the twentieth century. The invasion of grasslands by woody vegetation has also been claimed by Biswell (1956), Burcham (1957), Axelrod (1975), Aschmann (1977), and Cox (1984) as the result of changing fire intervals.

Were there more extensive grasslands in California in the eighteenth century than at present? The central problem in evaluating the Californian chaparral is the interpretation of the ambiguous chaparral taxonomy of the Franciscan diaries, those of Crespi and Serra, as well as those of Anza, Diáz, and Garcés who traversed southern California during the Anza Expeditions of 1772-1776 (Bolton 1927, 1930). All of these explorers were unfamiliar with Californian mediterranean vegetation. Indeed, Serra and Crespi explicitly stated that they had seen plants "never seen before." Descriptions of chaparral appear muddled because the physiognomic and floristic vocabulary for this community had not yet become standardized. It was only by Arrillaga's time that there was an established nomenclature for mediterranean vegetation, which he used in his diary, written 23 years into the Mission Period.

Unfortunately, Arrillaga was never commissioned to maintain a diary in Alta California for comparison with other Spanish explorations in that area.

Most striking is the difference in the way communities were described in the same places by Crespi and Arrillaga. In southern Ensenada Bay, Cañon Francisquito, and Cañon La Grulla, hillslopes were described by Crespi as dotted with small trees, rosemary, and small oaks. Arrillaga described them as covered by **chamizo** or **madroño**. Thus, statements such as "hills dotted with small oaks," which are interpreted by modern researchers as past oak savannas or woodlands, were probably chaparral.

We believe the challenge of this debate may be more related to the translation of Spanish diaries than to evidences of vegetation change. Indeed, the vagueness of these accounts may have contributed to interpretations of extensive vegetation change in Alta California.

7

THE FUTURE ROLE OF FIRE IN NORTHERN BAJA CALIFORNIA

The United States and Mexico form one of the most profound political boundaries in the world, dividing respectively, an industrialized, urbanized economy on the U.S. side from a "third-world" developing economy on the Mexican side. Differences in land use, especially in grazing and fire, in both countries have resulted in significant impacts on the natural vegetation. Space imagery and NASA highflight aerial photography show clear differences in plant communities that were homogeneous before the completion of a continuous fence separated the countries at the turn of the century (Bahre and Bradbury 1978; Humphrey 1987; Bahre 1991).

Along the Pacific coast, formerly homogeneous ecosystems have experienced similar differences in vegetation, not so much from exploitation as from "protective" management. One of the greatest differences across the frontier is the changing pattern of wildland fire as a result of protectionist management policies in California. North of the international boundary burns are catastrophic; in Baja California burns are frequent, small, and low in intensity.

This was not always the case. In the late nineteenth century, fire was not a threat to early European settlers in Alta California (Minnich 1987b, 1988), who were devoted to agriculture and grazing and made no attempt to control brushfires. Southern California newspaper accounts indicate that brushfires persisted for considerable periods and were brilliant spectacles admired for their beauty (Minnich 1987b). Lumbermen made ad hoc efforts to keep flames out of pine forests in the western San Bernardino Mountains but were ineffective. The fire/flood cycle caused by the denudation of wildlands became a public concern at the turn of the twentieth century, when wildlands were placed into public ownership in national forests and state parks. Fire exclusion management was introduced to protect the brushland and forest ecosystems from fires (Lockmann 1981; Pyne 1982).

Fire suppression has produced divergent impacts on ecosystems in California, depending mostly on the fuel characteristics of each. In coastal sage scrub, fire-cycle periods and fire size distributions are similar to those in Alta California (Minnich 1983). Apparently, the differences in transborder fire regimes in this ecosystem is minimized because fires carried by flashy herbaceous fuels frequently escape early control efforts. Similarly, in both Alta and Baja California, pinyon juniper woodlands experience long-interval stand-replacement fires that have recurrence intervals of centuries. Suppression has yet to cause a divergence in fire regimes in pinyon juniper forests in Baja California and the U.S. because the fuel buildup in

136

this unproductive ecosystem is limited even in 100 years (Wangler and Minnich 1997). Other unproductive ecosystems such as subalpine forests, Joshua Tree woodlands, and high desertscrub communities may have similarly experienced little impact from fire control.

In contrast, fire suppression in the chaparral of Alta California has contributed toward ever-larger fires, increasing uniformity of fuels, and higher fire intensities because uncontrolled fires escape in the severest fire weather such as during the Santa Ana winds (Minnich 1983; Minnich and Chou 1997). While fires are normally followed by increased sedimentation rates for several years, larger fires also punctuate temporal sediment yields because watersheds are more completely denuded over greater stream lengths (De Bano, Rice, and Conrad et al, 1979; Bonnicksen, 1980; Wells 1987).

Anthropogenic control of fire in forests of the western United States since 1900-1925 has also caused long-term changes in the composition and physiognomy in ponderosa pine and Californian mixed-conifer forests (Wright and Bailey 1982; Heinselman 1981a,b; Kilgore 1981; McKelvey and Johnston 1992). Fire dendrochronological studies in California (Weaver 1974; McBride and Lavin 1976; Kilgore and Taylor 1979; Swetnam 1993) show a trend of lengthening return intervals after the initiation of suppression in 1900-1920. In the San Bernardino Mountains of southern California, nearly 100 years of suppression has caused stand densities to increase from 100 stems per hectare in 1932 to 200 to 300 stems per hectare in 1992. Densities are locally as high as 900 stems per hectare (Minnich et al, 1995), and forests in the Sierra Nevada average 500 stems per hectare (Vankat 1977; Vankat and Major 1978; McKelvey and Johnston 1992). Forests in California also show an age-specific trend in which juvenile, pole-size cohorts of such forests are heavily dominated by *A. concolor* and *C. decurrens*, whereas mature, overstory cohorts are dominated by *Pinus ponderosa* and *P. jeffreyi* (Rundel, Gordon, and Parsons 1988; Barbour 1988; McKelvey and Johnston 1992). Stand-thickening and fuel buildup has led to enormous canopy fires covering tens of thousands of hectares, as have occurred at Yosemite, Stanislaus National Forest, and many areas of southern California (Weatherspoon, Husari, and van Wagtendonk 1992; McKelvey and Johnston 1992).

Until recently, isolation has protected the wildlands of northern Baja California, it has been accompanied by little or no fire control and by livestock grazing. Indeed, the low value and inaccessibility of vegetation resources in northern Baja California is responsible for the limited use of wildlands. Chaparral and mountain forests in the northern peninsula are marginally grazed because of poor forage, and brushlands provide low quality fuelwood. Few pine forests have been logged, and most have remained open and parklike because of periodic fire. Pinyon forest and desertscrub along the inaccessible eastern escarpments and deserts offer little to the economy. Fire control is practically nonexistent because much of the Peninsular Ranges are still accessible only by foot or horseback.

The isolation of northern Baja California is now being replaced by economic development. Although urban and agricultural growth were formerly concentrated in the rich Mexicali Valley and the border cities, the opening of the Transpeninsular Highway, as well as Highway 3 from Ensenada to San Felipe during the 1970s, has contributed to the rapid growth of agriculture and establishment of ejidos and villages along the San Quintín coastal

plain and in the San Telmo Valley. Secondary roads have been built into the Sierra Juárez and to the National Observatory in the Sierra San Pedro Mártir.

The increasing assessibility of the region presents both threats and opportunities. One threat is the prospect that management systems of industrialized countries, such as fire suppression, will be introduced and may result in irreversible changes that will make Baja California ecosystems indistinguishable from those in Alta California.

Maintaining ecosystems or restoring altered ecosystems requires knowledge of the past. Future land management in Baja California should critically examine the "well-managed" status of ecosystems in the northern peninsula: the fragmentation of brushlands by small fires, the openness of conifer forests, and the stability of ecosystem distributions as indicated by the comparison of Spanish diaries with present-day vegetation. Parts of Baja California probably duplicate a nineteenth-century landscape of California, against which management systems can be compared. Indeed, the northern peninsula could be a "showcase" of ecosystems functioning under natural-disturbance and traditional management systems that can be compared with similar temperate ecosystems in Alta California.

Evidence is strong that over the past centuries, periodic fires have not had permanent impacts on these fire-resilient ecosystems. This is because fire shapes ecosystem distributions, structure, and species composition by means of a spatially changing balance between the forces of combustion that remove biomass and those of the biological processes of establishment and growth, which selectively influences the distributions of ecosystems. Indeed, a passive response to wildfire and the use of deliberate burns in mature vegetation may be a good option for management in a region where natural fire has shaped landscapes.

Appendix A. Common Names of Important Species in Northern Baja California

(Spanish plant names from Spanish diaries, Martínez 1947; Tiscareño and Robinson 1969; Moran 1977a; Roberts 1989)

Species	Common name
Grasses and forbs	
Abronia villosa	Sand verbena
Achillea spp.	Yarrow
Aster spp.	Aster
Astragalus spp.	Locoweed, cascabelito, garbancillo
Avena barbata	Wild oat, avena
Avena fatua	Wild oat, avena
Berula erecta	Water parsnip
Brassica geniculata	Mustard
Brassica nigra	Black mustard
Brassica tournefortii	Sahara mustard
Bromus diandrus	Brome, ripgut
Bromus rubens	Red brome
Bromus tectorum	Cheat grass
Calandrinia maritima	Seaside calandrinia
Calochortus splendens	Splendid mariposa-lily
Camissonia crassifolia	Thick-leaved primrose
Carex spp.	Sedge
Castilleja exserta	Common owls-clover
Chaenactis glabriuscula	Pincushion
Chorizanthe coriacea	Lastarriaea
Chorizanthe fimbriata	Fringed spine-flower
Chorizanthe procumbens	Prostrate spine-flower
Cirsium foliosum	Thistle
Collinsia heterophylla	Chinese houses
Coreopsis californica	California coreopsis
Cryptantha spp.	Cryptantha, popcorn flower

139

Species	Common name
Delphinium parryi	Parry's larkspur
Dithyrea californica	Spectacle-pod
Epilobium adenocaulon	Willow-herb
Erodium cicutarium	Storks-bill, filaree, aguja del pasto, alfilaria
Eschscholzia minutifolia	California poppy, amapola amarilla
Galium sp.	Bedstraw
Hemizonia spp.	Tarweed
Hilaria rigida	Galleta grass, galleta
Juncus spp.	Rush, junco
Lasthenia californica	Coast goldfields
Layia platyglossa	Tidy tips
Mimulus brevipes	Monkey-flower
Muhlenbergia spp.	Muhlenbergia
Oenothera californica	California evening primrose
Perityle emoryi	Rock daisy
Phacelia hirtuosa	Phacelia
Phacelia parryi	Parry's phacelia
Platystemon californicus	Cream cups
Poa annua	Annual bluegrass
Polycarpon depressum	California polycarp
Potentilla spp.	Cinquefoil
Ranunculus cymbalaria	Buttercup
Schismus barbatus	Schismus
Scirpus spp.	Tule
Deciduous subshrubs	
Ambrosia chenopodifolia	Bur-shrub, huisapolito, huizapol
Ambrosia dumosa	Bursage, huizapol
Artemisia californica	California sage brush, romerito
Artemisia tridentata	Great Basin sage, chamiso blanco, chamiso ganado
Encelia californica	Bush sunflower
Encelia farinosa	Brittlebush, incienso
Ericameria arborescens	Goldenbush, rama hechicera
Eriogonum fasciculatum	Buckwheat, valeriana, maderistia, gordo lobo
Lotus scoparius	Chaparral pea, deerweed, jiguata

Species	Common name
Rosa minutifolia	Rose, rosa silvestre, rosa de castilla
Salvia apiana	White sage, salvia blanca, salvia orejona
Salvia clevelandii	Cleveland sage, salvia
Salvia mellifera	Black sage, salvia
Salvia pachyphylla	Rose sage, salvia rosa
Symphoricarpos parishii	Snowberry
Viguiera laciniata	San Diego bush sunflower, margarita
Deciduous shrubs	
Acacia greggii	Catclaw, cimmarón, zimmarón, uña de gato, palo chino
Aesculus parryi	Parry buckeye, trompo, berraco
Cercidium floridum	Palo verde, ypúa, dipúa, dipuga, medeja, medesa
Fraxinus trifoliolata	Three-leaf ash, chaparral ash, crucecilla, varejón, palo blanco, fresno
Olneya tesota	Desert ironwood, palo fierro, tesota, uña de gato, ypúa, dipúa
Prosopis glandulosa	Honey mesquite, mezquite, huisache
Prosopis pubescens	Mesquite, tornillo
Prunus fremontii	Desert apricot, durasnillo, damasquillo
Stem and leaf succulents	
Agave deserti	Desert agave, agave, mescal
Agave shawii	Coastal agave, maguey, mescal
Bergerocactus emoryi	Velvet cactus, cacto aterciopelado
Bursera hindsiana	Bursera, copal, copalquin, torote prieto
Echinocereus engelmannii	Hedgehog cactus, cacto fresa
Fouquieria columnaris	Boojum tree, cirio
Fouquieria splendens	Ocotillo, palo adán
Lemaireocereus thurberi	Organ pipe cactus, sweet pitahaya, pitahaya dulce
Machaerocereus gummosus	Sour pitahaya, pitahaya agria
Mammillaria dioica	Fishhook cactus, pincushion cactus, bisnaguita, vielita, llavina
Myrtillocactus cochal	Candelabra cactus, cochal
Nolina palmeri	Beargrass, nolina, palmita, sotol, amole
Nolina parryi	Beargrass, nolina, palmita, sotol
Opuntia acanthocarpa	Buckhorn cholla, cholla

Species	Common name
Opuntia basilaris	Beaver-tail cactus, prickly pear, nopal, tuna
Opuntia bigelovii	Teddy bear cholla, cholla, cholla del oso, ciribe
Opuntia cholla	Cholla, cholla pelona
Opuntia echinocarpa	Silver cholla, cholla
Opuntia littoralis	Prickly pear, nopal, tuna
Opuntia prolifera	Coast cholla, cholla
Pachycereus pringlei	Cardón
Yucca schidigera	Mojave yucca, dátil, dátillo
Evergreen sclerophyllous shrubs	
Adenostoma fasciculatum	Chamise, chamiso, vara prieta
Adenostoma sparsifolium	Redshank, chamiso de vara colorada
Arctostaphylos bolensis	Manzanita, madroño
Arctostaphylos glauca	Bigberry manzanita, manzanita, madroño
Arctostaphylos patula	Green-leaf manzanita, manzanita, madroño
Arctostaphylos peninsularis	Peninsula manzanita, manzanita, madroño
Arctostaphylos pringlei	Pinkbract manzanita, manzanita, madroño
Arctostaphylos pungens	Mexican manzanita, manzanita, madroño
Ceanothus cordulatus	Snowbush ceanothus, lilac, bracillo
Ceanothus cuneatus	Ceanothus, lilac, bracillo
Ceanothus greggii perplexans	Desert ceanothus, lilac, bracillo
Ceanothus leucodermis	Chaparral whitethorn, ceanothus, bracillo
Ceanothus oliganthus	Hairy ceanothus, lilac, bracillo
Ceanothus verrucosus	Ceanothus, lilac, bracillo
Cercocarpus betuloides	Birch-leaf mountain mahogany, ramón
Cercocarpus ledifolius	Curl-leaf mountain mahogany
Comarostaphylos diversifolia	Summer holly
Ephedra californica	Mormon tea, canatillo
Heteromeles arbutifolia	Christmas berry, California holly, toyon, fusique
Larrea tridentata	Creosote bush, gobernadora
Malosma laurina	Laural sumac, lentisco
Ornithostaphylos oppositifolia	Manzanita, palo blanco
Prunus ilicifolia	Holly-leaf cherry, islay
Quercus berberidifolia	Scrub oak, encinillo, encinito chaparro
Quercus cedrosensis	Scrub oak, encinillo, encinito chaparro

Species	Common name
Quercus cornellius-mulleri	Desert scrub oak, encinillo, encinito chaparro
Quercus turbinella	Desert scrub Oak, encinillo, encinito chaparro
Rhamnus californica	Coffeeberry, yerba de oso, cacachila
Rhamnus crocea	Spiny redberry
Rhus integrifolia	Lemonade berry, lentisco, mangle
Rhus kearneyi	Lentisco
Rhus ovata	Sugarbush sumac, lentisco
Simmondsia chinensis	Goatnut, jojoba, cocoba, cocovas
Xylococcus bicolor	Mission manzanita
Hardwood evergreen trees	
Quercus agrifolia	Coast live oak, encino, enzino
Quercus chrysolepis	Canyon live oak, encino
Hardwood deciduous trees	
Platanus racemosa	Western Sycamore, aliso
Populus fremontii	Fremont cottonwood, poplar, alamo
Populus tremuloides	Quaking aspen, alamillo, alameda tremblón
Quercus peninsularis	Pacific emory oak, encinillo
Salix spp.	Willow, sauce
Coniferous trees	
Abies concolor	White fir, abeto, pino blanco
Calocedrus decurrens	Incense cedar, cedro incienso, ciprés
Cupressus arizonica stephensonii	Arizona cypress, ciprés, cedro
Cupressus guadalupensis forbesii	Tecate cypress, ciprés, cedro
Cupressus montana	Mountain cypress, ciprés, cedro de la sierra
Juniperus californica	California juniper, ciprés, huata, cedro, tascale
Pinus attenuata	Knobcone pine, pino
Pinus contorta murrayana	Lodgepole pine, pino
Pinus coulteri	Coulter pine, pino
Pinus jeffreyi	Jeffrey pine, pino ponderosa, pino negro
Pinus lambertiana	Sugar pine, pino
Pinus monophylla	Singleleaf pinyon, piñon, ocote
Pinus muricata	Bishop pine, pino
Pinus ponderosa	Ponderosa pine, pino, pino ponderosa
Pinus quadrifolia	Parry pinyon, four-needle pinyon, piñon

Species	Common name
Palms	
Brahea armata	Blue fan palm, palma ceniza, palma azul
Washingtonia filifera	California fan palm, palma, palma de abanico
Washingtonia robusta	Mexican fan palm, palma, palma blanca

Appendix B. Place Names of Camps and Intervening Landscape Features Referred to in Text

(See Meigs (1935:10, 34-35). For linear or regional features such as arroyos or valleys, coordinates are given for locations as encountered by the diarists.Where the Linck, Crespi and Serra expeditions overlap, the place names of Crespi are given. The dates indicate the location of camp at day's end. Crespi's dates are shown without parentheses, Serra's with parentheses, and Linck's with brackets. Items shown without dates are land features explored during sorties on days when base camp had not moved. Modern names are taken from topographic sheets (scale:1:50,000) of Baja California (Mexico, DETENAL Instituto Nacional de Estadística, Geografica y Informatica [INEGI], Aguascalientes, México))

The Linck (1766) and Portolá expeditions (1769) from the Central Desert to the Sierra San Pedro Mártir

Date of Journey	Place-name of Spanish diarists	Modern place-name	Latitude (°north)	Longitude (°west)
Mar 23 (May 15) [May 9]	San Fernando Velicatá	San Fernando Velicatá	29° 58'	115° 14'
Mar 24	"dry arroyo"	Los Torotes	30 00	115 09
	"open country with good plains"	Valle las Animas	30 07	115 11
Mar 25 (May 16) [Mar 8]	San Juan de Diós	San Juan de Diós	30 09	115 15
Mar 26 (May 21)	Los Santos Mártires	Los Mártires	30 10	115 19
Mar 27 (May 22) [Mar 10]	Los Santos Mártires	Los Mártires	30 13	115 23
	"dry arroyo with some plains"	Lomas Amarillas	30 13	115 25
Mar 29 (May 23) [Mar 11]	Las Palmas	El Potrero near Rancho San Antonio	30 16	115 27
	"the country opened up wide"	Loma la Gringa	30 19	115 28
Mar 30 (May 24) [Mar 12]	San Angelo de Fulgino	Cañada los Alamos	30 22	115 27
Mar 31 (May 25) [Mar 13]	Arroyo de los Alamos	El Salto	30 28	115 26
Apr 1 (May 27) [Mar 14]	La Cieneguilla	-	30 32	115 24

Linck's explorations of the Sierra San Pedro Mártir and the Sonoran Desert (1766)

Date of Journey	Place-name of Spanish diarists	Modern place-name	Latitude (°north)	Longitude (°west)
[Mar 17]	"rested in an arroyo"	La Suerte (10 km SW)	30° 32'	115° 18'
[Mar 18]	"encamped in a valley"	El Represo, Rosarito	30 32	115 14
[Mar 19]	"glimpse of the Gulf of Calif."	near unnamed pass	30 32	115 11
[Mar 20]	"out of the sierra"	El Berrendo	30 34	115 07
[Mar 21]	"springs of varying...heat"	Agua Caliente	30 39	115 10
	-	La Gringa, Algodón	30 47	115 09
[Mar 23]	"proceeded along side of mtn."	Cañada el Barroso	30 49	115 13
[Mar 24]	"arroyo with much water"	Cañada el Cajón	30 51	115 14
[Mar 26]	"proceeded 5-6 hrs, northward"	Cañada la Providencia	31 00	115 15

145

Franciscan journeys to San Diego (1769)

Sierra San Pedro Mártir foothills

Date of Journey	Place-name of Spanish diarists	Modern place-name	Latitude (° north)	Longitude (° west)
Apr 1 (May 27)	La Cieneguilla	-	30° 32'	115° 24'
	"bad and narrow pass"	La Rinconada	30 35	115 25
	(Santa Humiliana)	San José	30 37	115 26
Apr 3 (May 28)	San Ricardo	San Pablo	30 41	115 27
Apr 4 (May 29)	San Isidoro (San Fernando)	San Isidoro	30 46	115 33
Apr 6 (May 31)	San Vicente Ferrer	Cañon San Antonio near		
	(Santa Petronilla)	Rancho San Antonio	30 48	115 38
Apr 8 (Jun 1)	San Dionisio	arroyo of San Antonio		
		near San Antonio	30 49	115 42
Apr 10 (Jun 2)	Valladares	Valladares	30 52	115 42
Apr 11 (Jun 3)	"mesa to high hill"	-	30 53	115 46
Apr 12 (Jun 4)	"spacious plain in the mtns."	Rancho el Carricito	30 53	115 52
Apr 13	"descended to a large valley"	east end of Valle San		
		Telmo	30 56	115 56
Apr 14 (Jun 5)	La Poza de San Telmo	5 km east of San Telmo	30 58	116 04
Apr 16 (Jun 9)	San Rafael	San Rafael	31 05	116 05
Apr 17 (Jun 10)	San Bernabé	El Salado	31 12	116 10
Apr 18 (Jun 11)	Marsh of Santa Isabel	San Vicente	31 20	116 16
Apr 19 (Jun 12)	Arroyo Seco de los Alisos	Cañon Santa Cruz near		
		Las Cruces	31 24	116 21

Central basins

Date of Journey	Place-name of Spanish diarists	Modern place-name	Latitude (° north)	Longitude (° west)
Apr 20 (Jun 13)	Beato Jacobo Ilírico	Agua Grande (spring)	31° 26'	116° 24'
Apr 21 (Jun 14)	San Anselmo	Cañon el Chocolate	31 31	116 25
Apr 22 (Jun 15)	San Francisco Solano	Valle Santo Tomás	31 33	116 25
Apr 23 (Jun 17)	San Jorge	Cañon la Grulla,		
		Uruápan	31 37	116 26
Apr 26 (Jun 18)	Los Santos Mártires	Cañon San Francisquito	31 42	116 27
Apr 27 (Jun 19)	"rough gorges, up and down"	Cañon San Carlos	31 47	116 27
May 1	Hollow of the Holy Apostles	Cañon San Carlos,		
		Valle el Maneadero	31 46	116 35
May 2 (Jun 21)	Bahía Todos Santos	Ensenada	31 52	116 37

North coast

Date of Journey	Place-name of Spanish diarists	Modern place-name	Latitude (° north)	Longitude (° west)
May 4 (Jun 23)	Pools of Santa Mónica	El Sauzal	31° 54'	116° 42'
May 7 (Jun 24)	"very stony arroyo"	Cañon Arce	31 56	116 40
	San Estanislao	W. Valle Guadalupe	32 00	116 40
May 8	"valley resembled a cornfield"	San Marcos	32 00	116 42
May 9 (Jun 25)	mesa of San Juán Bautista	Boquilla de Santa Rosa	32 01	116 46
May 10 (Jun 26)	San Juán Bautista	La Misión de S. Miguel	32 05	116 52
	"wide green valley..., estuary"	Boca el Descanso	32 12	116 55
May 11 (Jun 27)	El Vallecito de San Pío	El Rosarito	32 16	117 02
	Los Cuatro Coronados	Islas las Coronados	32 20	117 16
May 12 (Jun 29)	Pool of Holy Martyrs	Tijuana	32 26	117 01
May 13 (Jun 30)	Sancti Spiritus	Tijuana at US/MEX border	32 31	117 03

Longinos-Martínez's traverse of the Sierra San Pedro Mártir (1792)

Date of Journey	Place-name of Spanish diarists	Modern place-name	Latitude (° north)	Longitude (° west)
Jul 17	Mission Santo Domingo	Mission Santo Domingo	30° 46'	115° 57'
	Valladares	Valladares	30 52	115 42
	source of stream at Valladares	El Descanso	30 54	115 37
Jul 17	"rest, or small plain"	Cañon Santa Cruz	30 54	115 35
	"a summit"	La Zanja	30 53	115 31
	first "level place"	La Grulla	30 53	115 28
	"beautiful valley," Las Animas	La Encantada	30 53	115 24
	"steep, high, and rocky peaks"	Tres Palomas	30 53	115 22
Jul 18	"great water," El Carmen	Santa Rosa	30 48	115 21
Jul 19	Valle San Rafael	Valle Chico	30 52	115 11
Jul 20	"highest part of the mountains"	near central valley (La Encantada), Cerro. Botella Azul	30 58	115 25
Jul 21	"a flat...without any plants,"	Vallecitos	31 00	115 31
	a slope gentle and free of stones	La Corona, La Puerta	30 59	115 35
Jul 22	La Concepción	Cieneguita de Soto	30 58	115 36
Jul 23	Mission Santo Domingo	Mission Santo Domingo	30 46	115 57

Arrillaga's first journey: to Santa Catarina (1796)

Date of Journey	Place-name of Spanish diarists	Modern place-name	Latitude (° north)	Longitude (° west)
Jul 21	San Vicente	San Vicente	31° 20'	116° 16'
	"narrow arroyo"	Cañon Agua Caliente	31 23	116 10
	"followed the same stream"	Cañon Dolores	31 26	116 05
	"narrow and rocky arroyo"	Cañon San Lorenzo	31 28	116 01
	San Pablo	San Pablo	31 30	115 58
	"stream to the right"	Cañada el Rincón	31 34	115 52
Jul 22	Santa Catalina	Santa Catarina	31 39	115 49
Jul 23 (day trip)	arroyo to north,...bends east	El Tule, Las Palomas	31 47	115 48
Jul 24 (day trip)	sierra north and northeast	Cañada el Rincon	31 42	115 45
(day trip)	Puertezuelo	Puertezuelo, Cañada Jamín	31 38	115 41
Jul 25	"wide plain with shallow lakes"	SE plain of El Alamo (Llano Dos Guatas)	31 32	115 47
	La Trinidad	Valle la Trinidad	31 24	115 44
Jul 26	Agua Caliente	Valle la Trinidad	31 23	115 47
	Los Encinos, Our Lady of Pilar	Los Encinos	31 20	115 55
	Zacatón	Salado	31 18	116 00
	San Luis, Los Coches	Cañon los Cochis	31 19	116 04
	San José	Cañon San José, Cañon el Canoso	31 20	116 10
Jul 27	San Vicente	San Vicente	31 20	116 16

Arrillaga's second journey: to San Felipe (1796)

Date of Journey	Place-name of Spanish diarists	Modern place-name	Latitude (° north)	Longitude (° west)
Aug 2	San Vicente	San Vicente	31° 20'	116° 16'
Aug 3	Mission Santo Domingo	Santo Domingo	30 46	115 57
Aug 6-21	Mission San Pedro Mártir	Mission San Pedro Mártir (ruins)	30 47	115 28
	La Encantada	La Encantada	30 53	115 24
Aug 22 (reconaissance)	eastern escarpment	La Encantada,ridge to E	30 55	115 22
Aug 23	"treacherous arroyo"	Cañada el Cajon	30 51	115 16
	"some hills of...rock"	Sierra San Felipe	30 56	115 02
Aug 24	San Felipe de Jesús	San Felipe	31 02	114 50
Aug 25	"opening...in some bare mtns.	Cañon las Cuevitas	31 02	115 05

Arrillaga's second journey: to San Felipe (1796) (continued)

Date of Journey	Place-name of Spanish diarists	Modern place-name	Latitude (° north)	Longitude (° west)
	"two leagues of sand"	La Salada de Sta. Clara	31° 02'	115° 14'
Aug 26	San Elías, "arroyo leaves great Sierra toward the east"	Cañada Esperanza or Cañada El Copal	31 07	115 25
Aug 28	La Vieja	Valle Santa Clara near Cañada la Vieja	31 17	115 27
	San Matías	Valle San Matías	31 19	115 32
Aug 29	Agua Caliente	Valle la Trinidad	31 23	115 47
Aug 30	Los Encinos, Our Lady of Pilar	Los Encinos	31 20	115 55
Aug 31	San Vicente	San Vicente	31 20	116 16

Arrillaga's third journey: to the Sierra Juárez, Valle San Rafael, and Valle Guadalupe (1796)

Expedition to the mission

Date of Journey	Place-name of Spanish diarists	Modern place-name	Latitude (° north)	Longitude (° west)
Aug 31-Sep 4	San Vicente	San Vicente	31° 20'	116° 16'
Sep 5-Sep 10	Santo Tomás	Santo Tomás	31 33	116 25
	La Grulla	Can. la Grulla, Uruápan	31 37	116 26
Sep 11	La Grulla	Cañon la Grulla	31 30	116 20
	"top of a hill"	Rancho el Pedregoso	31 40	116 12
	"spacious ravine"	El Porvenir	31 43	116 06
	"flat plain"	El Pescado	31 46	116 06
Sep 12	San Salvador	San Salvador	31 50	116 04
	Jesús María	Sangre de Cristo	31 52	116 09
	"reaching the heights of the sierra"	Rancho la Choya	31 53	116 02
	"reached a summit"	El Candado	31 53	115 55
Sep 13	Santa Isabel	Santa Isabel	31 52	115 50
Sep 14	"examined the escarpment"	Cañon Santa Isabel	31 52	115 47
	descent of a steep arroyo	Cañon Santa Isabel	31 53	115 42
Sep 15	"arroyo with palms"	Cañon Santa Isabel	31 54	115 40
	"arroyo...receives other arroyos of the sierra"	Arroyo Grande, and area 25 km to the south	31 55	115 38
	"trail...through some mesas"	Arroyo Grande	31 53	115 37

Expedition to the mission (continued)

Date of Journey	Place-name of Spanish diarists	Modern place-name	Latitude (°north)	Longitude (°west)
Sep 16	"chain of hills"	Sierra las Tinajas	31°50'	115°33'
	"prominent low point"	Portezuelo	31 37	115 37
	Arroyo Agua Caliente	Arroyo Agua Caliente	31 40	115 39
	"reach the heights"	Cañada el Jamin	31 38	115 41
Sep 17	Santa Catalina	Santa Catarina	31 39	115 49

Return trip through the Sierra Juárez

Date of Journey	Place-name of Spanish diarists	Modern place-name	Latitude (°north)	Longitude (°west)
Sep 18	Santa Isabel	Santa Isabel (via El Tule, Las Palomas)	31°52'	115°50'
Sep 19	"2 1/2 hours north of S. Isabel	Potrero de Marcos	32 00	115 52
	La Laguna	Laguna Hanson	32 03	115 55
Sep 20	"two leagues N of La Laguna"	Agua Amarga	32 07	115 55
Sep 21 (day trip)	a canyon of the escarpment forming a "side of 'C'"	Cañon el Carrizo or Cañon la Milla [ElTajo]	32 15	115 55
	San Mauricio, "a large and spacious canada	La Matanza	32 05	115 57
	first arroyo	Valle Redondo	32 03	116 01
Sep 22	"another spacious sink"	La Casa Verde	32 05	116 05
	"a sink with sufficient pasture"	La Rosa de Castilla	32 03	116 07
	"where all the arroyos unite"	El Barbón	31 58	116 08
	"green sink"	La Huerta	31 55	116 08
Sep 23	Valle San Rafael (SR)	eastern Valle SR, (Valle Ojos Negros)	31 53	116 08
	"crossed the plain"	Puerta Blanca	31 53	116 17
	"northeast side" of S. Rafael	Jacalitos, De Cota	32 02	116 18
Sep 23	"arroyo where the waters of the valley (SR) come down"	El Barbón	32 02	116 22
	"a sink"	Rancho Bueno Aires	31 57	116 19
	"sierrita"	Cerro Portezuelo	31 57	116 17
	"two small meadows"	Ojos Negros	31 56	116 19
Sep 24	"base camp"	Real del Castillo Viejo	32 00	116 21
Sep 25	"cañada of many oaks"	Cañada de los Encinos	32 04	116 29

Date of Journey	Place-name of Spanish diarists	Modern place-name	Latitude (° north)	Longitude (° west)
	Valle San Marcos	eastern Valle Guadalupe	32° 07'	116° 30'
	"impassable gorge"	Cañon el Burro	32 10	116 30
Sep 26	San Marcos	San Marcos	32 00	116 42
	El Tigre	El Tigre	31 57	116 45
	El Carmen	El Carmen	31 56	116 43
Sep 27	Ensenada de Todos Santos	Ensenada	31 52	116 36
Sep 28	Santo Tomás	Santo Tomás	31 33	116 25
Sep 30-Oct 13	San Vicente	San Vicente	31 20	116 16

Arrillaga's fourth journey: to the Colorado River and San Diego

Date of Journey	Place-name of Spanish diarists	Modern place-name	Latitude (° north)	Longitude (° west)
Oct 14	"Campsite of July 21"	Cañon Agua Caliente	31° 23'	116° 10'
Oct 15	Santa Catalina	Santa Catarina	31 39	115 49
Oct 16	Agua Caliente	Agua Caliente	31 37	115 35
Oct 17	"chain of hills"	Sierra las Tinajas	31 45	115 30
	"a short but bad slope..."	Sierra las Tinajas	31 45	115 27
Oct 18	"sand dunes,...a well"	Tres Pozos	31 49	115 19
	mouth of Rio Colorado	Rio Colorado	31 50	114 58
Oct 19-20	Rio Colorado	Rio Colorado	32 00	115 07
Oct 22	"plain west of Rio Colorado"	-	31 54	115 25
	"arroyo with palms"	Cañon Santa Isabel	31 54	115 40
	San Cristobal	Cañon de Guadalupe	32 10	115 47
Oct 23	"sierra...forms an arch"	La Poderosa	32 22	115 48
	"large indentation in sierra"	international boundary	32 38	115 52

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153

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